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JOURNAL

Early History of Amateur Motion-Picture Film • *Glenn E. Matthews and Raife G. Tarkington* 105

Perceptibility of Flutter in Speech and Music • *Frank A. Comerci* 117

A Light Meter for Printer Control • *A. J. Sant, M. C. Goddard and O. E. Miller* 123

High-Speed Photography Notes—Errata and Lacunae 125

Separation Process for Additive Color Motion-Picture Photography on Black-and-White Film • *Lawrence F. Brunswick* 126

Combat Television • *Edward L. Scheiber and Hugh C. Oppenheimer* 129

Equipment for Evaluating Lenses of Television Systems • *Edgar Hutto, Jr.* 133

Electronic Comparator for the Automatic Inspection of Magnetic Sound Prints • *Jerome W. Stafford* 137

Proposed American Standard, Magnetic Coating of 8mm Motion-Picture Film 140

Letter to the Editor 140

Contents continued on inside back cover

77th Convention • April 18-22 • Chicago

ADVANCE PROGRAM IN THIS ISSUE

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Early History of Amateur Motion-Picture Film

By GLENN E. MATTHEWS and RAIFE G. TARKINGTON

A review is given of the status of motion-picture films for amateur use prior to 1923. Up to that date, lack of standardization of film size, the use of the negative-positive method, and cost of apparatus and printing held back extensive use of film for amateur motion pictures. Research in the manufacture of safety acetate film support was started by Eastman Kodak Co. in 1906–1907, and limited quantities of film were manufactured and sold between 1912 and 1923. Film on safety acetate base, a fundamental requirement for home movies, was introduced in 1912 for a portable projector made by Thomas A. Edison, Inc., and also for equipment made by Pathé Frères, a French firm. A safety film 9.5mm wide, introduced by Pathé Cinéma in 1923, was developed either to a negative, or directly to a positive by the conventional reversal method.

Research on film for amateur motion pictures was started in 1914 by Eastman Kodak Co. and led to the introduction of the Ciné-Kodak process on January 8, 1923. A safety film 16mm wide was used which was developed directly to a positive by an improved reversal process using controlled second exposure. The factors are analyzed that made this process successful and encouraged the standardization of 16mm film throughout the world. Included is a short account of the processing of 16mm films, of improvements in 16mm film emulsions, the printing of duplicates, the use of sound on 16mm film, the history of 8mm reversal film, and the introduction of amateur motion pictures in color.

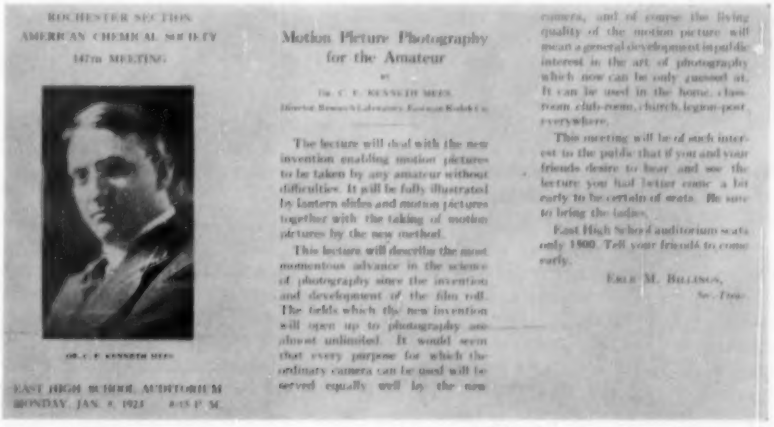
In 1888 George Eastman coined a slogan, "You press the button — we do the rest," expressing the simplicity of the new era in still photography introduced by the first "Kodak" camera and roll film. Thirty-five years later, the simplicity of still photography was extended to motion pictures with the announcement on January 8, 1923, of the Ciné-Kodak process using a new film 16mm in width and developed by a reversal process. The announcement was made at a joint meeting of several technical societies in East High School, Rochester, N.Y. (Fig. 1). On that occasion motion pictures were made on the new 16mm safety film of several members of the audience, processed to a positive by reversal and projected at the end of the lecture. The new film and the method of processing were described to the Society of Motion Picture Engineers[1] at their semi-annual meeting in Atlantic City, N.J., in May 1923. This development raised the curtain on a new era in the field of motion pictures for the amateur with portable equipment. During the 30 years that have followed the introduction of the reversal process for amateur motion pictures, the use of 16mm film has expanded very extensively both for amateur and professional applications.

In the quarter century before 1923 many attempts had been made by numerous inventors and firms to introduce equipment and film that would provide motion pictures for home use (Table I). Several of these systems have been described by Crawford, Stull and others.[2] Most of these systems used the negative-positive process which was costly and probably accounts in large measure for their limited commercial success.

Motion-picture film as first supplied by Eastman and used by Edison in 1889 was on nitrate support, 35mm wide, which is the same width that is still used in the theater today although the picture dimensions have been changed from time to time. One of the first attempts to make apparatus using a narrower-width film was that of Acres (London) who in 1898 slit the 35mm negative lengthwise to make two filmstrips, each 17.5mm wide, perforated along one side. His camera was called the "Birtac" and the picture made with it was about half the standard 35mm frame. Subsequently, many others adopted a film 17.5mm wide with various types of perforations for use with their equipment. Other film widths that were used included 22mm, 21mm, 15mm and 11mm, some of which are shown in Figure 2. Many of these early films were exposed, printed and shown on the same piece of equipment. Most of these earlier films were coated on highly inflammable nitrate supports.

The Significance of Safety Acetate Film Base for Amateur Motion-Picture Use

In 1912 Thomas A. Edison, Inc., Orange, N.J., announced the Edison Home Kinetoscope (Fig. 3) which used cellulose acetate safety film 22mm wide (Table I and Fig. 2), developed to a negative, and printed. This safety film was supplied by the Eastman Kodak Co. who were convinced that only safety film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147th MEETING

Motion Picture Photography for the Amateur

The lecture will deal with the new invention enabling motion pictures to be taken by any amateur without difficulties. It will be fully illustrated by lantern slides and motion pictures together with the taking of motion pictures by the new method.

This lecture will describe the most momentous advance in the science of photography since the invention and development of the film roll. The fields which the new invention will open up to photography are almost unlimited. It would seem that every purpose for which the ordinary camera can be used will be served equally well by the new camera, and of course the living quality of the motion picture will mean a general development in public interest in the art of photography which now can be only guessed at. It can be used in the home, class-room, club-room, church, legion-post, everywhere.

This meeting will be of such interest to the public that if you and your friends desire to hear and see the lecture you had better come a bit early to be certain of seats. Be sure to bring the ladies.

East High School auditorium seats only 1800. Tell your friends to come early.

EARL M. BILLINGS,
Sec.-Treas.

EAST HIGH SCHOOL AUDITORIUM
MONDAY, JAN. 8, 1923 8:15 P. M.

Fig. 1. Program announcing lecture about 16mm Ciné-Kodak process on January 8, 1923.

Presented on October 22, 1954, by Norwood L. Simmons for the authors, Glenn E. Matthews and Raife G. Tarkington, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on August 2, 1954.)

should be used for amateur motion pictures. This conviction was emphasized as shown by the following quotation from Mr. Eastman's letter to the Edison Company, dated June 4, 1912: "Concerning the cellulose acetate film which we are furnishing you for your Home Kinetoscope, we beg to say that we believe the article to be a perfectly safe one for use in such an apparatus or we would not consent to supply it. In our opinion, the furnishing of cellulose nitrate for such a purpose would be wholly indefensible and reprehensible."

Also in 1912, the French firm of Pathé Frères introduced portable motion-picture equipment using 28mm film with a cellulose acetate support.[3] The acetate-type base and the 28mm width of film were recommended by A. F. Victor[4] in 1918 as a standard for portable projectors. In his plea for the adoption of the new standard, Victor pointed out the grave importance of using only safety film in portable projectors for use in the home, the school, and other locations where safety from fire hazards is paramount. A standard was adopted in April 1918, by the Society of Motion Picture Engineers[5] for a safety standard film 1.102 in. (28mm) wide for portable projectors. It differed slightly from Pathé 28mm film but Pathé projectors could take the new 28mm standard film (Fig. 4).[6]

Research in the manufacture of a non-inflammable motion-picture film support by the Eastman Kodak Co. began in 1906–1907 and the results seemed so successful that by 1909 the Kodak Company was prepared to give up manufacture of nitrate and go entirely to acetate film.[7] Limited quantities of 35mm film on acetate support and some 22mm and 28mm film were supplied to the trade between 1912 and 1920. Experimental work was continued, especially after World War I, and after a great deal of research and many trials, a better product was made available for use in the 16mm Ciné-Kodak process and equipment as well as equipment made by other manufacturers. The research continued and improved safety films were introduced from time to time until today safety film support is made and used almost exclusively throughout the world.[8]

Table I. Chronology of Motion-Picture Film for the Amateur (1898–1923.)*

Year	Name	Film width, perforation location	Support type	Inventor or manufacturer
1898	Birtac	17.5mm perf. along one side	nitrate	B. Acres (London)
1900?	Biokam	17.5mm perf. in center	nitrate	Wrench & Son (London)
1900	Mirographe	21mm notched on each edge	nitrate	Reulos, Goudeau & Co. (Paris)
1900?	La Petite	17.5mm, 1 square perf. in center	nitrate	Hughes (London)
1900	Pocket-Chrono	15mm center perf.	nitrate	L. Gaumont & Co. (Paris)
1902	Vitak	17.5mm center perf.	nitrate	W. Wardell (a mail-order project)
1903	Kino	17.5mm center perf.	nitrate	Ernemann (Dresden)
1905?	Ikonograph (first projector that could reverse the movement of the film)	17.5mm	nitrate	E. J. Rector (N.Y.) (Ikonograph Commercial Co. of Manhattan, N.Y.)
1910	Empire Cinematograph	35mm	nitrate	W. Butcher & Son, Ltd. (London)
1910	Picturescope	35mm with 2 rows of pictures	nitrate	Chas. E. Dressler (N.Y.)
1911	Animatograph	Spiral film disk	nitrate	A. F. Victor (Davenport, Iowa)
1912	Duoscope	17.5mm with two center perf.	nitrate	
1912	Pathé K-O-K in France	28mm, 3 perf. on 1 edge; 1 perf. on other edge	safety	Pathé Frères (Paris)
1913	Pathescope in U. S.	Same as Pathé K-O-K	safety	Pathescope Co. (N.Y.)
1912	Home Kinetoscope	22mm, 3 rows of pictures, perf. between rows	safety	Thomas A. Edison, Inc. (Orange, N.J.)
1914	Atlas	35mm	nitrate	Atlas Educational Film Co. (Chicago, Ill.)
1914	Animatograph	35mm	nitrate	Victor Animatograph Co. (Davenport, Iowa)
1915	Animatograph (Model 2)	35mm	nitrate	Victor Animatograph Co. (Davenport, Iowa)
1917	Victor Projector	35mm	nitrate	Victor Animatograph Co. (Davenport, Iowa)
1914	Ensign Cinematograph Camera	35mm	nitrate	Houghton's Ltd. (London)
1913	Spirograph	Images on circular film disk in spiral order	nitrate	Charles Urban Trading Co., Ltd. (London)
1915	Sinemat	17.5mm	safety	Sinemat Motion Picture Machine Co.

Early Research on Amateur Motion Pictures by Eastman Kodak Company

In 1914 F. W. Barnes, then manager of the Hawk-Eye Works of the Kodak Company, demonstrated at the Research Laboratory an experimental camera that had been built several years earlier for exposing two rows of pictures along short lengths of 35mm film, one row being exposed on the first run through the camera, much as 8mm film is exposed today (Fig. 5a). The film was developed to a negative and then printed in the conventional way. To project the film the camera was converted to a projector by replacing the back with a lamphouse.

J. G. Capstaff, of the Research Laboratory staff, saw the demonstration and asked if he might borrow the camera for experimental use on an idea for amateur motion pictures. From 1914 to 1916 he worked with this equipment from time to time and began almost immediately to develop the exposed films directly to a positive using a variation of the procedure that was recommended for *reversal* development of Lumière Autochrome Screen Plates* (Fig. 5b). He became convinced that reversal processing and high-quality pictures would succeed commercially where other methods had failed.[10] He felt that the reversal process, which eliminates the need for additional film for the positive print and the printing operation, would reduce greatly the excessive cost of motion pictures for the amateur. Then, by making easy-to-use, low-cost equipment a method would be available to do for the potential motion-

* The reversal process of photographic development was described originally in 1899 by R. Namias.[9]

Year	Name	Film width, perforation location	Support type	Inventor or manufacturer
1916–1917	DeVry	35mm	nitrate	H. DeVry Co. (Chicago, Ill.)
1915–1916?	Autograph	17.5mm	nitrate?	
1915–1916?	Duplex	11mm, 2 round perf. on each edge	nitrate?	G. J. Bradley
1917	Safety Cinema	28mm, 3 perf. on each edge	safety	A. F. Victor, Victor Animatograph Co. (Davenport, Iowa)
1917	Movette	17.5mm, 2 circular perf. on each edge	nitrate neg. safety pos.	Movette Camera Co. (Rochester, N.Y.)
1917	Simplex	35mm	nitrate	Simplex Corp. (Long Island, N.Y.)
1917	Cub	35mm	nitrate	American Cinematograph Corp. (Chicago, Ill.)
1918	Actograph	17.5mm	nitrate	Wilart Instrument Co. (New Rochelle, N.Y.)
1920	Home Cinema	28mm-Pathescope	safety	Victor Animatograph Co. (Davenport, Iowa)
1920	Clou	17.5mm, 2 perf. per frame	nitrate	Firm name unknown (Austria)
1920	Sept.	17 ft of 35mm motion pictures or 250 still pictures	nitrate	A. Debrie (France)
1921	Coco	17.5mm	nitrate	Linhof (Munich)
1921	Defranne	35mm	nitrate	Bass Camera Co., (Chicago, Ill.)
1921	Kinamo	35mm	nitrate	Ica, A.G. (Dresden)
1922–1923	Pathé-Baby or Pathex	9.5mm, 1 center perf. between frames	safety, dev. to a positive by reversal	Pathé Cinéma (Paris)
1923	Baby Standard	35mm	nitrate	Vicam Photo Appliance Corp., (Philadelphia, Pa.)
1923	Ciné-Kodak	16mm	safety, dev. by controlled reversal	Eastman Kodak Co. (Rochester, N.Y.)
1923	Victor	16mm	safety	Victor Animatograph Co. (Davenport, Iowa)
1923–1924	Filmo	16mm	safety	Bell & Howell Co. (Chicago, Ill.) first spring-motor-driven camera

* Based on survey of the literature; but list may not be complete.

picture amateur what roll film and the snapshot camera had done for the amateur still photographer.

In 1916, the preliminary results were shown to Mr. Eastman. At first he was reluctant to enter a field of manufacture in which so many other firms had been unsuccessful. However, Mr. Capstaff's demonstration of the quality of small picture images obtainable by using the reversal process and the assurance that an appreciable lowering of cost would result from the adoption of this method encouraged Mr. Eastman to regard the proposal more favorably and he gave his approval that a development program should be started. At this time Mr. Eastman restated his conviction that only safety film should be used for amateur motion pictures and only this type of film has been manufactured by the Eastman Kodak Co. for this purpose.

Early in the experimentation (before 1916) it appeared that images made by reversal were of finer grain than those that were developed to a negative. This encouraged trials to be made of smaller picture areas than the standard 35mm size. Various apertures such as $\frac{1}{4}$, $\frac{1}{8}$ and $\frac{1}{6}$ that of the 35mm size frame in use at that time (1-in. by $\frac{3}{4}$-in.) were tried in the Barnes experimental camera. With the film emulsions then available, it was decided that a picture $\frac{1}{6}$ of the area of the standard frame was the smallest that could be used and still give good picture quality. Upon calculation this gave a picture area 10mm by 7.5mm and, allowing 3mm on each edge for perforation, resulted in a film 16mm wide and carrying 40 pictures to the foot. This smaller size reduced still further the cost of this method, and also it was advantageous in that chances of using nitrate (by splitting 35mm, for example) were very much lessened.

The reversal process of development, as generally used, consists essentially of the following steps: (1) a first development to form a negative image, (2) bleaching of the image with acid-bichromate or acid-permanganate to change the negative image to a soluble salt of silver that can be dissolved out, (3) a full exposure to light and (4) finally developing *all* of the remaining silver halide completely to form a positive image.[11]

The first experiments by Capstaff with the reversal process used these well-established procedures. However, this process as applied to film available at that time had two disadvantages.[1] It gave satisfactory results only through a limited range of original exposures and variations in the evenness of coating of the film emulsion resulted in inferior quality in the final, positive image. During the early research (before 1917) Capstaff[12] worked out a method that used a *controlled* second exposure or re-exposure which overcame these major disadvantages.

If a heavy or full exposure is given in the camera, much of the silver will be developed at the beginning, and when this is removed, there will only be a small amount of silver halide left for the production of the positive. A very heavy second exposure to light is then desirable, otherwise the positive image will not have enough density. On the other hand, if the camera exposure is light or on the short side, there will be a great deal of undeveloped silver halide available to form the final image, and a short second exposure is desirable, as otherwise too dense an image will be produced. Therefore, by the proper control of the second exposure during processing, the effective latitude of the reversal film was increased.

When complete re-exposure is used, variations in thickness of the emulsion will show up as a density difference, resulting in mottle, streakiness and other defects in the final image. With controlled re-exposure all the residual silver halide is not, in most instances, exposed completely; and the defects, while not eliminated entirely, are greatly reduced, in effect. This variable or controlled

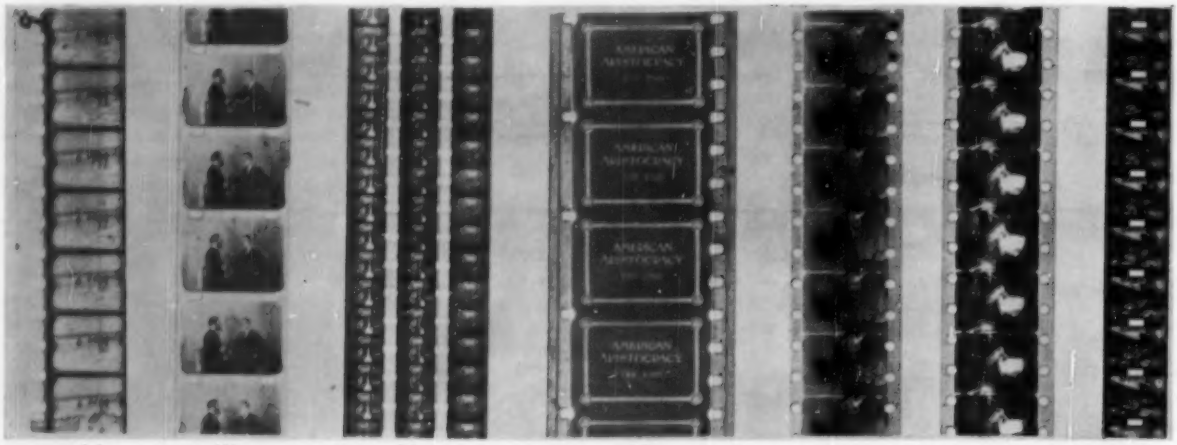


Fig. 2. Several varieties of film widths available before 1923: (a) Birtac—17.5 mm (1898); (b) Duoscope—17.5 mm, center perforation (1912); (c) Edison Home Kinetoscope—22 mm (1912); (d) Pathescope—28 mm (1912); (e) Movette negative and positive—17.5 mm (1920); (f) Pathex—9.5 mm (1923). (See Table I)

second exposure has been considered an important phase of reversal processing of Ciné-Kodak black-and-white films for many years.

The "timing," as it is called, of this second exposure was done in this experimental stage by exposing separate frames of a short length of the scene to different intensities of light. When developed, the correct exposure to be given the rest of the film could then be judged by examination of this test strip.

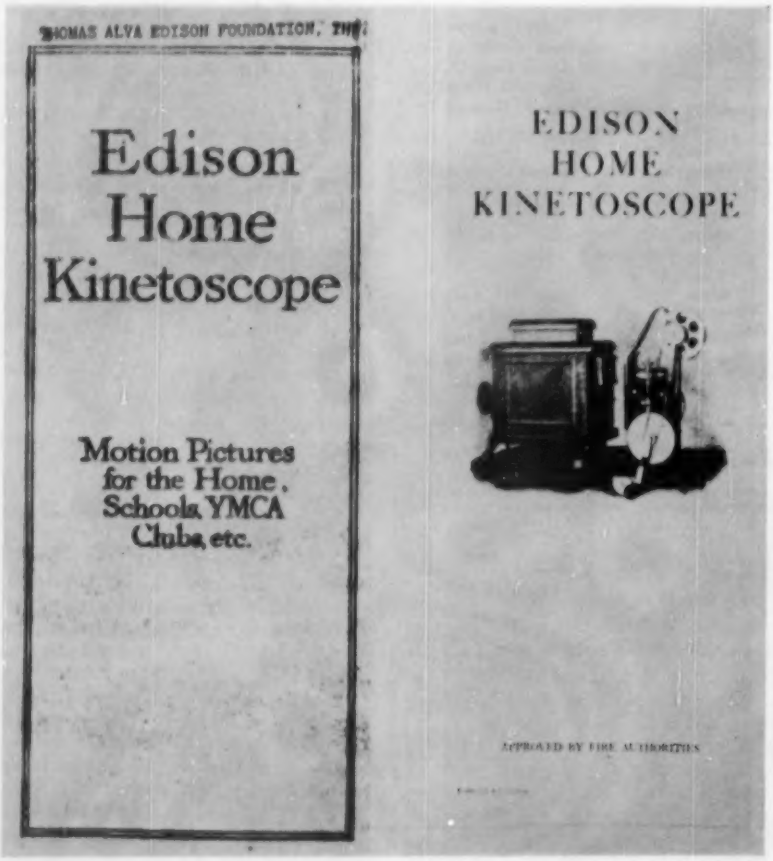


Fig. 3. Edison Home Kinetoscope booklet (cover and frontispiece), April 12, 1912. (Courtesy Thomas Alva Edison Foundation, Inc.)

Another modification in the conventional reversal process invented by Capstaff[12] was the addition to the first developer of a silver halide solvent and a hardening agent. The former gave clearer highlights in the resulting image and the latter prevented reticulation of the gelatin during subsequent chemical treatment.

Work on the process was discontinued during World War I but was resumed early in 1919. Many experiments were conducted to determine the emulsion, the formulas and the processing conditions that gave the best results. The design of a camera, perforator, and projector built to precision requirements was carried out by the Hawk-Eye Works. The prototype of the Model A Ciné-Kodak was completed early in May 1920 (Fig. 6), and the projector some months later (Fig. 7), and both were turned over to Capstaff for testing. He worked in close collaboration with the film manufacturing departments at Kodak Park and tried out many coatings of film. An orthochromatic emulsion on acetate base was finally chosen. Black paper leader and trailer on each 50- and 100-ft roll permitted daylight-loading. The film had two perforations (rounded-end type) per frame located one at each side on the frame line. The first perforator for 16mm safety film was built in the spring of 1920 and put into use by the film department early in May 1920 (Fig. 8). The rectangular perforation with rounded corners was adopted in January 1923, and is still in use. Although the first films did not have antihalation backings, these were found necessary to control halation and considerable research was conducted on the best type of backing for suppressing such effects. Examples of early reversal test pictures on 16mm film are shown in Fig. 9.

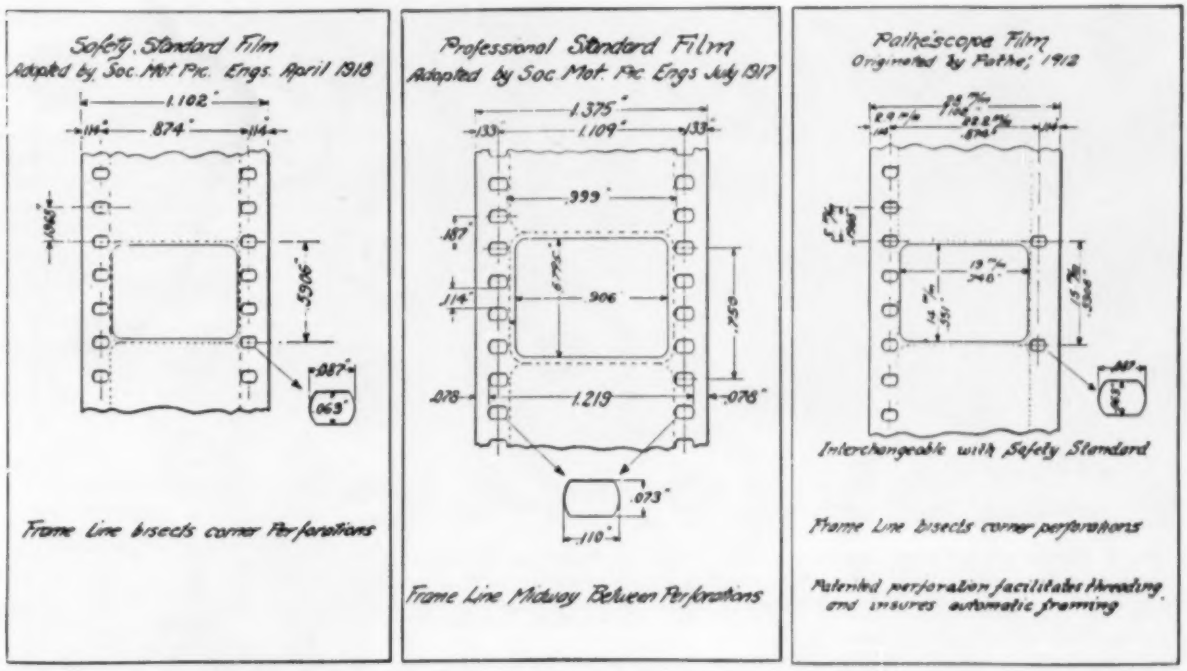


Fig. 4. Comparative sizes of Pathescope film (1912), 28-mm Safety Standard (SMPE—April 1918) and Professional Standard (SMPE—July 1917). (Reproduced from *Motion Picture Photography for the Amateur* by H. C. McKay, Falk Publishing Co., New York, 1924.)

Introduction of the Ciné-Kodak Process

By the latter part of 1922 development work had progressed sufficiently that it was decided by the Kodak management to place the Ciné-Kodak process on the market the following year. In talks and demonstrations given before several technical societies during 1923, it was pointed out[1] that the new system of amateur motion-picture photography was founded on "the use of film smaller than that used in the standard camera and on a new process for finishing it, the object being to reduce the cost of the finished picture to as low a point as possible" (Fig. 10). Actually, it was estimated that the new process cut the cost of motion pictures to $\frac{1}{8}$ that of the negative-positive method — a very significant saving. An advertisement for the Ciné-Kodak appeared in the New York Times and the New York Tribune on July 5, 1923 (Fig. 11).

In discussing the advantages of the new reversal process, it was indicated that images developed with it were "astonishingly free from graininess" partly as a result of the special film but largely as a result of the reversal process itself, the largest grains and clumps of grains formed during first development being removed by the bleach, leaving the smallest grains to be developed as the final positive image.[1]

Because of the special equipment and skill required to develop the film, the Kodak Company decided in 1923 to establish a policy that they would undertake, for a time at least, the work of processing all the film that was exposed with the cameras in use.

The reversal process with controlled second exposure was an instant success. There is little doubt that it was this development that determined the success of the 16mm program of amateur motion pictures. Other factors were good equipment design for processing the film

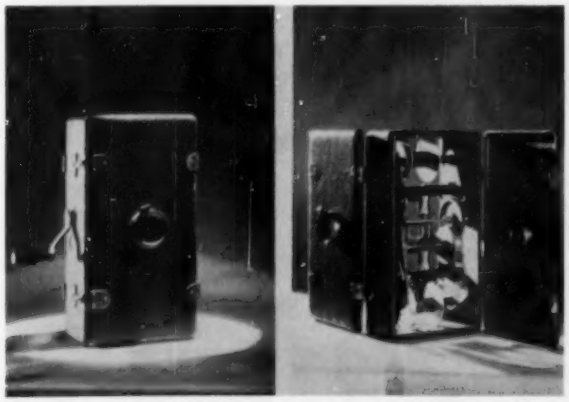


Fig. 5a. Barnes experimental camera (closed and open) for exposing two rows of images linearly on short lengths of 35mm film.

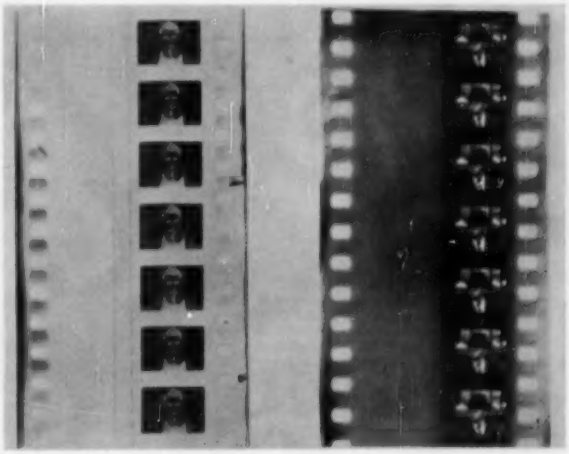


Fig. 5b. Negative and reversal-positive test films exposed by J. G. Capstaff with Barnes experimental camera.

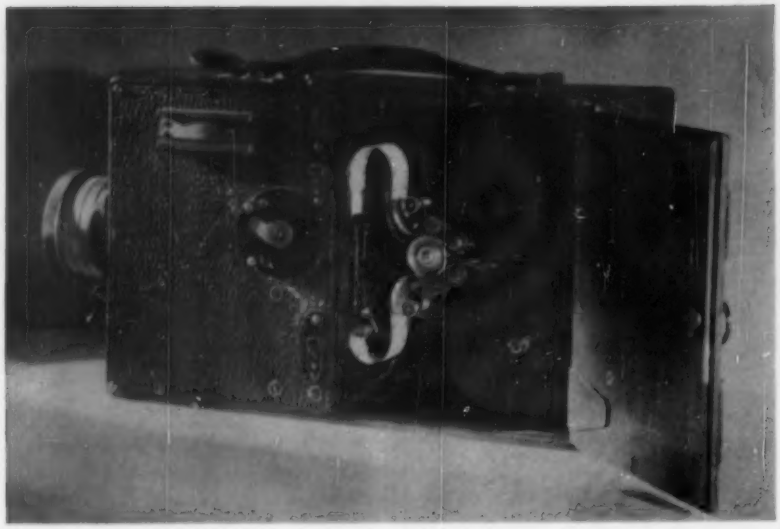


Fig. 6. Altered original 16mm camera used by J. G. Capstaff for experimental research with 16mm reversal film (1920–1922). Original camera about 2/3 as long as camera shown; section added about 1924 permitted use of longer focal length lenses.

and a world-wide distribution and service facilities.

In his first lectures about the new process when comparing the cost of a single scene by motion pictures or as a snapshot, C. E. K. Mees[1] said, "On the whole, it appears as if amateur cinematography . . . will not be more expensive to the user than is still photography."

In commenting on this development A. F. Victor[12] in 1923 stated: "The reversal process has lowered the cost of picture-making to a point never before considered possible. At such a low cost it is almost certain that motion picture cameras and projectors may become as universal as still hand cameras." Victor also suggested that 16mm safety film should be standardized for home use. A standard for 16mm safety film was proposed by the SMPE in May 1924 (Fig. 12), and approved by the American Engineering Standards Committee in April 1928.

Within the year of 1923 the Victor Animatograph Co. (Davenport, Iowa) and the Bell & Howell Co. (Chicago, Ill.) introduced equipment using the new 16mm film, recognizing the probability that it would become a standard for home use.

Interest in amateur motion pictures was encouraged and fostered in this country by the Amateur Cinema League which was founded in 1927. The first issue of the League's official publication *Amateur Movie Makers* appeared in December 1926.

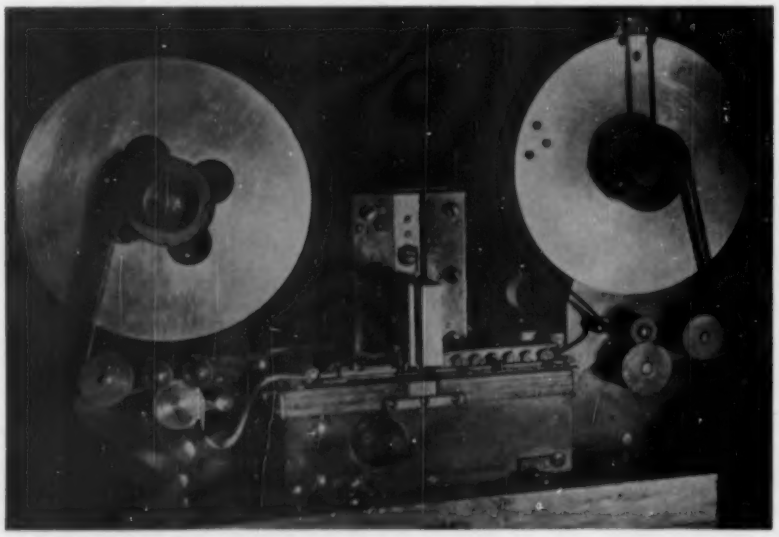


Fig. 8. First perforator for 16mm film (1920–1923).

Processing Apparatus for 16mm Ciné-Kodak Films

At first all 16mm reversal test films were processed with a hand-cranked reel and a tank of 50-ft capacity. Subsequently the processing was done on a so-called twin-reel machine consisting of two developing reels arranged end to end, each of 100-ft capacity, and above them, one 200-ft capacity drying reel. Each reel had two parallel, circular, hard rubber end-plates connected by glass rods. The film was wound spirally on one reel and became immersed in the processing solution as the reel was rotated manually. Motorized units of these machines were installed in Rochester in 1923, in Chicago in March 1924, and in San Francisco by

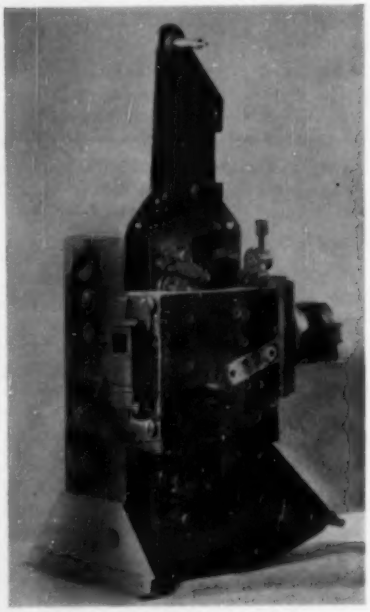


Fig. 7. Experimental 16mm projector (1920–1923).

1925. A hand-controlled light was used for the "timing" of the re-exposure, the amount of light being determined by the judgment of experienced operators.

The twin-reel machine did not have enough capacity for quantity processing and work began in 1923 on the design of a continuous processor known as the "tube machine." It consisted of a long series of vertical glass tubes, each 6-ft long, through which the film moved in a sinuous path driven by sprockets between consecutive tubes. Manual control of a density step tablet was used for the second exposure and the operator set it by judgment for each scene change. With a machine of this type it was possible to process hundreds of feet of film continuously.

Because of mechanical difficulties, glass

(a) (b) (c)

Fig. 9. Examples of early reversal pictures on 16mm film (about twice actual width): (a) May 1920—first tests—W. Vaeth; (b) Sept. 1920—Rochester Horse Show—H. B. Tuttle; (c) July 1922—children at play—J. G. Capstaff.

breakage and problems of control related to replenishment, agitation and temperature encountered with the tube machine, a tank-type machine was designed in which the film was wound on a series of rolls in spiral form passing several times from the top to the bottom of each of several tanks. The tank machine was more compact than the tube machine and also permitted continuous processing of long lengths of film (Fig. 13). Improved methods of agitation, temperature control, replenishment and drying were devised. Early in 1925 the first tank machine was installed in Rochester at Kodak Park. Later these machines were installed in processing stations in several cities in this country as well as in stations throughout the world. Subsequently, a small tank machine was designed and a group of machines was built for use in the processing stations having a lower volume of work. Several of these smaller machines were installed on cruise ships that went around the world and permitted the amateur 16mm camera-users to see their pictures while en route. These installations were removed within a year or so as soon as processing stations were set up in different countries throughout the world.

Fig. 10. Comparison of relative sizes of 35mm (standard) images and 16mm reversal image.

The Automatic Printer for Controlled Re-Exposure

With the increase of production on the continuous machines it became apparent that manual control of re-exposure was difficult to perform consistently and offered many supervisional problems. The

HE NEW YORK TIMES, THURSDAY, JULY 5, 1923.
The Ciné-Kodak for motion pictures
You can now make motion pictures the Kodak way. Ciné-Kodak offers a new simplicity, a new economy, a new compactness. It opens wide the door to personal motion pictures.
Just announced, but you can see it here.
Eastman Kodak Co.
Madison Ave. at 45th St.
The MAR-CAR
Starts Today
THE SEMI-ANNUAL REDUCTION OF WHITEHOUSE & HARDY SHOE
Special Price
BOTH SHOPS
WHITEHOUSE & HARDY
Business Opportunities
NIC CITY.

Fig. 11. Early advertisement of Ciné-Kodak process, New York Times, July 5, 1923.

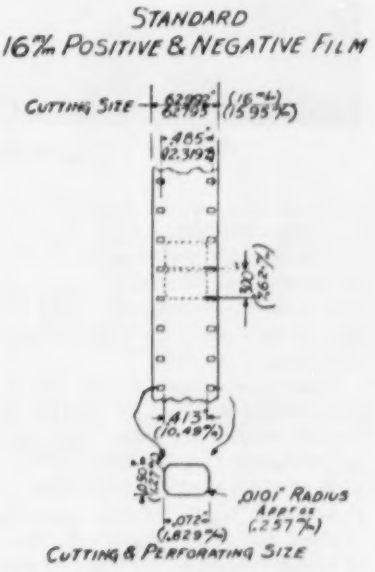


Fig. 12. Proposed SMPE Standard for 16mm film (1924). (Reproduced from *Trans. SMPE*, No. 18, 238, May 1924.)

Research Laboratories were assigned the problem of design of an automatic printer. Results of experiments were sufficiently good that an order was placed in February 1927, to build a number of them for distribution to existing processing stations.

The system of re-exposure used a source of non-actinic light and a thermopile to control the intensity of the printing light. The current from the thermopile, produced by the heating effect of the non-actinic light passing through the film, controlled the movement of a galvanometer vane that was interposed in the optical system and this, in turn, varied the amount of actinic light that was projected on the film. Thus the printer exposure was dependent upon the current in the thermopile and, therefore, upon the transmission of the red light by the residual silver halide (positive) image in the film.[14]

Many control problems arose and required solution during the attempt to improve the quality of processing, such as measurement of developer activity, methods of replenishment, control of the stability of bleach solution, recovery of silver, and so on. Expert supervision of quality control at processing stations throughout the world has insured the maintenance of a high level of picture quality throughout the years.

Pathé 9.5mm Reversal Film

Just before Christmas of 1922, the French firm of Pathé Cinéma (formerly Pathé Frères) introduced in France under the name of "Pathé Baby"[15] a small projector for projecting films 9.5mm wide. At the same time films 9.5mm wide by 8.5 meters long, with a single perforation in the center between frames, and wound on a special spool were made available for use with the projector. The subject matter of these films was obtained by reduction printing from 35-mm professional motion pictures which had already been shown in theaters belonging to the Pathé Company, and a library of these films, known as Pathé Library Films, was established (Fig. 14).

Encouraged by the initial acceptance of this small film and projector system for home entertainment and realizing that only half the amateur motion-picture enthusiast's desire had been satisfied, Pathé Cinéma designed a 9.5mm motion-picture camera for amateur use. Experiments with reversal processing of 9.5mm film were conducted in December 1922 by L. Didiée of Pathé Cinéma.* In December 1923, this camera and an orthochromatic negative film, 9.5mm wide by 10 meters long and with center perforations, were placed on the market. Since it was planned that the film could be reversal-processed by the customer, a developing outfit, consisting of two tanks and a combined frame on which three loops of film could be placed, was made available at the same time.

The negative film was processed, whether by the customer or by a laboratory, by reversal development, thus, like the 16mm Ciné-Kodak process, eliminating the cost of printing and print film stock. The second (positive) development was either by the use of an uncontrolled full exposure to light followed by development, or directly by the use of a solution containing hydrosulfite which converted the remaining silver halide to a black silver image.[16] Customer processing apparently gave generally inferior results and the amateurs soon started sending their films to the Pathé Cinéma factory where precise control of processing conditions gave assurance of a more satisfactory product. Controlled second exposure during processing was not employed by the Pathé factory until 1936 when its use was begun for the same reasons that this method has been used in the 16mm Ciné-Kodak process. The 9.5mm Pathé Baby process of complete home motion pictures became very popular in France and has continued to be used quite widely there to the present day.

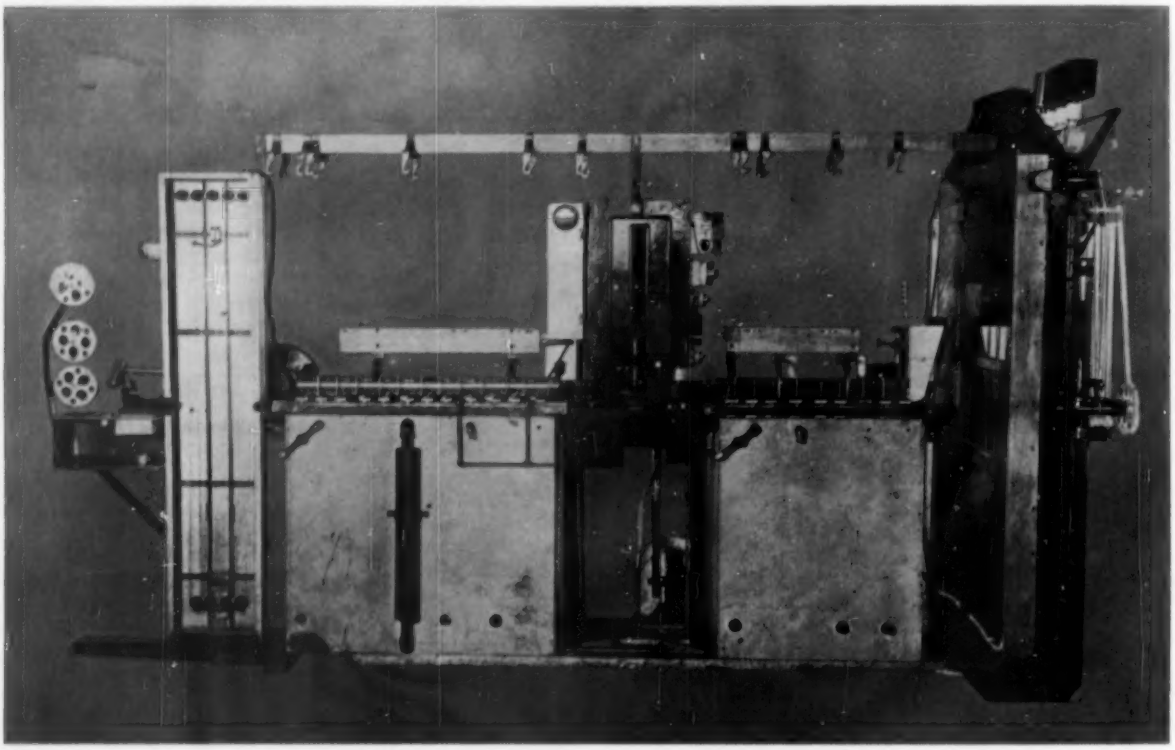
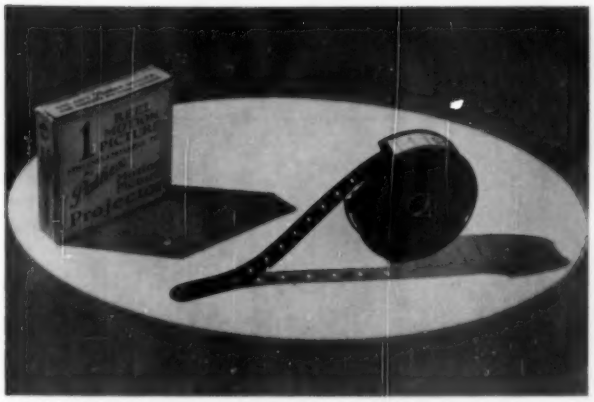


Fig. 13. Early tank-type processing machine for 16mm reversal film (1925).

* Private communication, March 31, 1954.



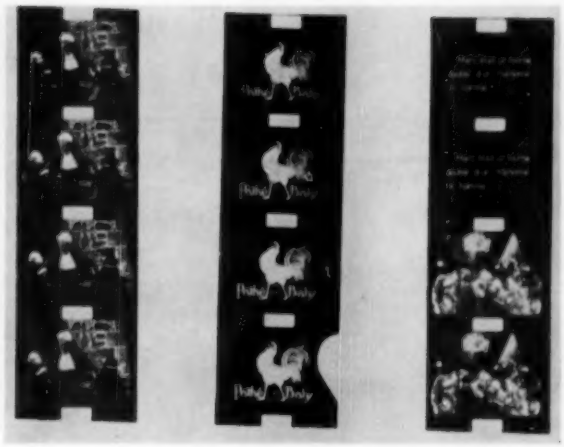


Fig. 14. (Above) Pathex (Pathe Baby) film carton and reel; (right) examples of Pathex films.

Other Reversal Films

Subsequent to the introduction of Ciné-Kodak Safety 16mm Film and Pathé 9.5mm film, other manufacturers introduced reversal films including those made by Agfa,[17] Gevaert, Mimosa, Ilford, Ansco and Du Pont.

Duplication of 16mm Reversal Films

The need for occasional duplicate prints was recognized from the beginning when 16mm reversal film was first introduced. In his early paper on the film,[1] Mees indicated that the making of extra prints was "provided for by use of a special printer in which a positive can be duplicated, the duplicate being reversed into a positive in the same way as the original picture," and at the same cost as the original picture. After the duplicating service was established in 1924 for making duplicates of films taken by the amateur, it made possible the use of this service for certain professional motion-picture purposes and probably encouraged wider use of 16mm film. Subsequently a variety of subjects became available for educational, industrial and other uses. This type of material was frequently made by reduction printing from 35mm film negatives. Libraries of educational and entertainment films were made available for the amateur and served to increase his general interest in amateur motion pictures.

Research and Development of Improved Ciné-Kodak Films

As noted previously, the first Ciné-Kodak Film was an orthochromatic emulsion coated on safety acetate support. From the beginning a research program has been in progress constantly to find ways of improving the quality of both the support and the emulsion. Problems of stripping, halation, resolution and many other difficulties have been studied and thousands of experiments made to overcome them. Reversal processing imposes stringent requirements upon the uniformity of coating thickness. In recent years improvements in the manufacture of reversal films have been made so that thickness variations are not now as serious a limitation on the picture quality as when the film was first introduced.

In 1928 Ciné-Kodak Panchromatic Film was introduced. This step insured better tone reproduction, particularly when photographing subjects having orange or red colors. It gave improved quality of tones in close-ups of people. In 1931 improved methods of sensitizing and new sensitizing compounds[18] resulted in the introduction of Super Sensitive Ciné-Kodak Panchromatic Film and in 1938 Super-XX Ciné-Kodak Panchromatic Film was introduced.

Sound on 16mm Reversal Film

Not long after the rapid growth of sound on 35mm film started in 1927–1928, interest began to grow in the problem of recording sound records on 16mm reversal film. The first sound records used were on disks synchronized with the picture film. Although the first projector[19] for 16mm sound films did not appear on the market until 1930 (Model PG-30 manufactured by the Radio Corp. of America), research in the problem of sound recording and reproduction on 16mm film began in the Kodak Research Laboratories in 1927. Considerable research was done because it was difficult to process both pictures and sound track simultaneously, since each type of record had different density, speed and gamma requirements. A steady light source, for example, is required for the second exposure of the sound track in contrast to a variable-intensity light for the re-exposure of the picture. Special 16mm film emulsions were developed by Kodak and others for separate recording without pictures for professional use.

In 1929 the Eastman Kodak Co. suggested the use of 16mm film having one row of perforations along one side, leaving the other edge of the film available for the sound track. A standard for this type of 16mm sound motion-picture negative and positive was proposed by the Society of Motion Picture Engineers in 1932[19] (Fig. 15), and adopted by the American Standards Association in 1935. Considerable research has been conducted in the problem of optical printing of 16mm sound tracks by reduction from 35mm records.[20]

History of the 8mm Reversal Film

Steady progress in emulsion manufacture toward finer grain and more speed between 1923 and 1928 made it possible to consider even smaller-sized motion pictures than 16mm film. Serious attention was given in 1928 at the Kodak Research Laboratories to the idea of a

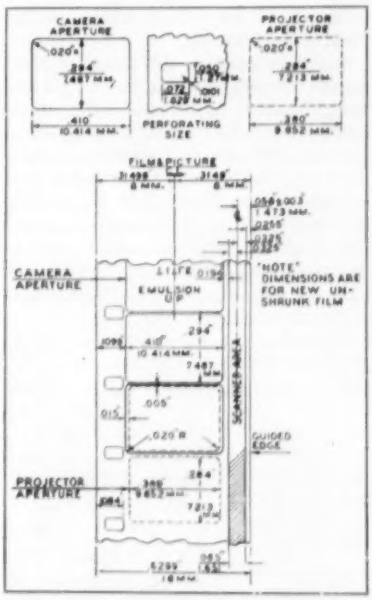


Fig. 15. Proposed Standard for 16mm Sound-On-Film (1932). (Reproduced from *Jour. SMPE*, 19: 478, Nov. 1932.)

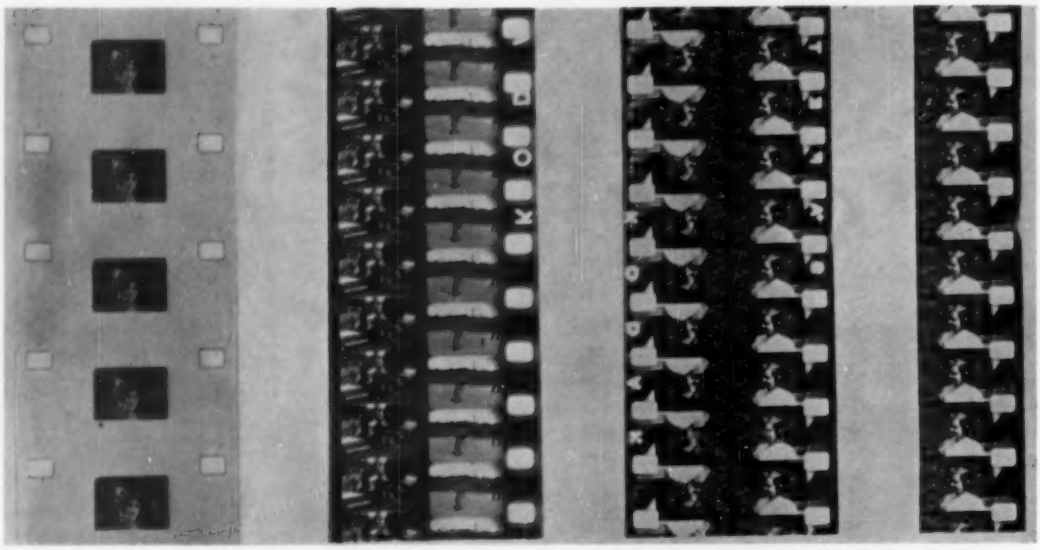


Fig. 16. Early experiments on 8mm film images and examples of unslit and slit "double-eight" film: (left) 5-mm image reduction-printed; (left center) 8mm experiment on single perforated 16mm film; (right center) standard 8mm pictures before slitting; (right) standard 8mm picture after slitting. (All films twice actual width.)

film one-half the size of 16mm although experiments had also been done by Capstaff on even narrower-width films (Fig. 16). While a smaller-sized film offered the possibility of further economies in amateur motion pictures, reducing the size from 16mm to 8mm does not reduce the cost in the same proportion. The operations of manufacturing, packaging, handling and processing remain essentially unchanged whether the film size is 16mm or 8mm. In order, therefore, to realize the reduction in cost commensurate with the reduction in film size to 8mm it was considered necessary to use existing 16mm equipment as far as possible.

Based in part on the Barnes experimental camera used in the very early work in the 16mm reversal process and on other inventions, a camera was built in 1930–1931 that would expose two rows of pictures linearly on 16mm film by exposing one row and rethreading the film and then exposing a second row (Fig. 16). The film spool and the two camera spindles were so designed that the user could only thread the film in the correct way.

After development in a 16mm processing machine, the film is slit down the center and spliced end to end. Two hundred feet of this film are equivalent in projection time to 400 ft of 16mm or 1000 ft of 35mm film. Each picture on 8mm film is about one-fourth the size of a 16mm frame. Cameras and projectors for 8mm film were marketed by Kodak in August 1932,[21] and subsequently by several other manufacturers.

The extremely small size of the 8mm film image required the development of emulsions and processing solutions which would give a reversal image of very high resolving power and definition. New perforators had to be built for this film, slitters had to be supplied to the processing stations and a new automatic printer designed to give the controlled reexposure to two rows of pictures differing in subject matter. With continuing improvement in photographic equipment and materials, the use of 8mm film for strictly amateur home movies is increasing rapidly, while the 16mm size is being used more and more extensively for nontheatrical-type purposes, such as in schools, churches, industry and science.

Introduction of Amateur Motion Pictures in Color

For more than a hundred years it has been the dream of nearly every experimenter in photography to produce pictures in natural colors. In this field the Kodak Company and several other firms have been experimenting since the early years of this century. Prior to 1925, however, no process of color motion-picture photography was considered by the Kodak Company to fulfill the requirements that would permit its

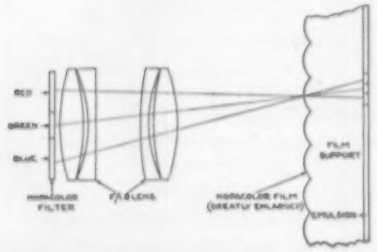


Fig. 17a. Diagram of Kodak lenticular film (1928).

Fig. 17b. Picture on Kodacolor film of child with red hat (A) against blue sky (B), showing displacement of lines in these two areas.

adaptation to a simple process for color motion pictures for the amateur.

In 1925, rights were acquired by the Eastman Kodak Co. from Société du Film en Colours Keller-Dorian to adapt the additive color process of R. Berthon, a French inventor, to amateur cinematography. Berthon's lenticular screen process was originally patented in 1908. As finally worked out by Kodak and introduced under the name *Kodacolor*[22] in July 1928, it consisted of a panchromatic 16mm film having embossed on its film support hundreds of tiny cylindrical lenses (about 560 in an inch) extending lengthwise of the film (Fig. 17). For exposure in a standard 16mm camera, a banded three-color filter was placed over the camera lens. When the film is threaded into the camera with the base side toward the lens, the embossed lenses guide the rays from each of the three filters during exposure and impress these filtered images on the emulsion. After processing by reversal, a monochrome positive image is produced which becomes a color picture when projected with a projector having a banded three-color filter over its lens.

To make a successful process, a great deal of study was involved such as standardization of the embossing operation, making a suitable panchromatic emulsion and working out the best reversal processing conditions. The utmost care had to be taken to avoid dirt, surface irregularities and other possible causes of trouble with the lenticulated support during manufacture and processing of the film, otherwise color distortions would be produced when the film was projected. The major disadvantages of the Kodacolor process were the large loss of light in both the taking and projecting steps resulting from the use of filters, and the necessity of maintaining the optics, particularly those of the projector, to very close alignment.

The Kodacolor process was used successfully for several years. However, it lost favor quite rapidly with the amateur soon after the introduction of the Kodachrome process, which used a subtractive-type film that gave a brighter projected image and was considered easier for customers to use.

The German firm, Agfa, introduced a lenticular 16mm film called Agfacolor[23] in 1932, but this film also lost favor with the amateur after the introduction of a subtractive-type multilayer film.

Dufaycolor, another additive process, was introduced in 1934 for use in 16mm amateur motion pictures.[24] A regular mosaic screen or réseau was produced on the film support and then a fast panchromatic emulsion was coated over the mosaic screen. Exposure was made through the film base. The mosaic screen consisted of a geometrical pattern of blue and green squares separated by red lines, producing roughly one million color filter elements per square inch. The film was developed by reversal and gave a color image on projection.

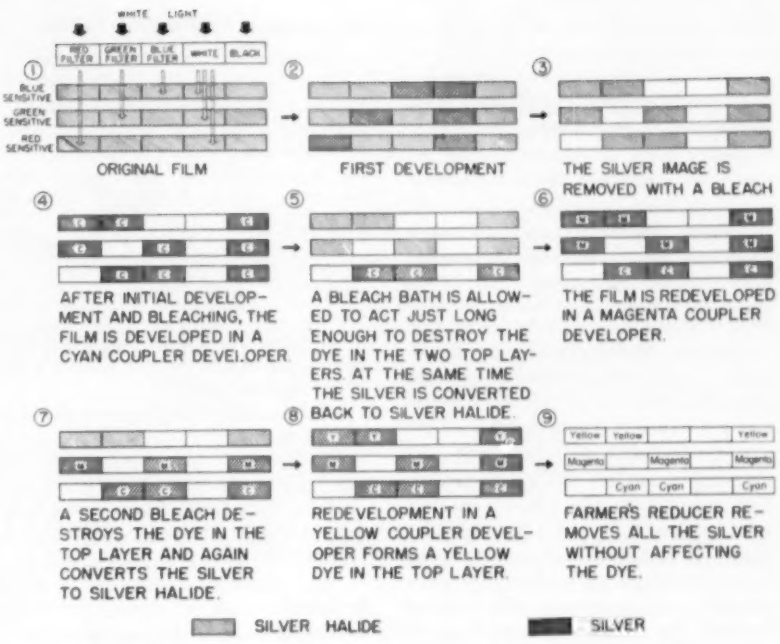

WHITE LIGHT
RED FILTER
GREEN FILTER
BLUE FILTER
WHITE
BLACK
BLUE SENSITIVE
GREEN SENSITIVE
RED SENSITIVE
ORIGINAL FILM
FIRST DEVELOPMENT
THE SILVER IMAGE IS REMOVED WITH A BLEACH
AFTER INITIAL DEVELOPMENT AND BLEACHING, THE FILM IS DEVELOPED IN A CYAN COUPLER DEVELOPER.
A BLEACH BATH IS ALLOWED TO ACT JUST LONG ENOUGH TO DESTROY THE DYE IN THE TWO TOP LAYERS AT THE SAME TIME THE SILVER IS CONVERTED BACK TO SILVER HALIDE.
THE FILM IS REDEVELOPED IN A MAGENTA COUPLER DEVELOPER.
A SECOND BLEACH DESTROYS THE DYE IN THE TOP LAYER AND AGAIN CONVERTS THE SILVER TO SILVER HALIDE.
REDEVELOPMENT IN A YELLOW COUPLER DEVELOPER FORMS A YELLOW DYE IN THE TOP LAYER.
Yellow
Magenta
Cyan
FARMER'S REDUCER REMOVES ALL THE SILVER WITHOUT AFFECTING THE DYE.
SILVER HALIDE
SILVER

Fig. 18. Diagram of the early Kodachrome process (1935–1938).

Multilayer Color Films Involving Reversal Development

The use of multiple-coated films having three emulsion layers, each sensitive to one of the three primary colors, has been suggested by various inventors from time to time. In 1912, R. Fischer, a German experimenter, proposed that chemical substances (later called couplers) be incorporated in each of the three emulsion layers of a multilayer color film. During development these substances would combine with oxidized developing agents to form dyes such as cyan, magenta and yellow.[25] This process required couplers and sensitizers that would remain within a layer and not wander into the next layer, and cause color degradation. In the existing state of knowledge at that time and for some years later this ingenious process was not converted to commercial practice.

In the Kodachrome process, developed by L. Mannes and L. Godowsky, Jr., in collaboration with the Eastman Kodak Co. and as originally marketed as 16mm film in 1935, the multilayer film contained only the sensitizing dyes, the couplers being in the developer solution.[26] After exposure, the film was developed to a negative and the negative image in each of these layers was removed by bleaching with permanganate. The film was then given a fixed exposure to light to make the silver bromide images developable and the whole film was developed to produce a cyan dye in all three layers. After drying, the film was treated with a bleach of low penetration which removed the dye from the top and middle layers and regenerated the silver bromide which was then developed to form magenta images. The film was dried again and treated with a very low penetration bleach which removed the magenta dye from the top layers and converted the silver to silver bromide, so that it could be used to form a yellow dye image. The remaining silver was then changed to silver halide and removed by fixing, leaving the three dye images which formed the positive color image (Fig. 18). Although slow and clumsy, this process was operated successfully by skilled technicians for a few years.

With this type of reversal process, controlled second exposure is not practical. Nevertheless, the process uses a modified form of reversal development and much research has been done to work out special bleaches and other processing details. In 1936, Kodachrome 8mm film was announced, thus making color motion pictures available to the many users of 8mm equipment. In a new method of Kodachrome processing introduced in 1938 a simpler form of reversal process was used.[27]

Color motion pictures by the Kodachrome process can be made by anyone as easily as making ordinary black-and-white motion pictures because the complex phase of producing the color pictures, the color development of the film, is done at processing stations or laboratories under precise technical control.

In 1936, in Germany the new Agfacolor 16mm film was announced which is a commercial realization of Fischer's

process. In this process, as marketed at that time, a coupler which will not wander was incorporated in each of the three emulsion layers and the dye images were formed during development.[38] Subsequently, other multilayer reversal 16-mm color films have been introduced including Ansco Color, Ilford Color and Gevacolor. Duplicating reversal color films have been made available as color print films for 16mm use.

Summary

This short historical survey has shown how motion pictures for the amateur came into wide commercial use within a few years after the introduction of the Ciné-Kodak process which was announced in January 1923. This process used a new safety film 16mm wide that was developed by the film manufacturer by an improved reversal process incorporating the unique feature of controlled second exposure. This process lowered the cost of amateur motion pictures in several ways: (1) it used a small-sized film having $2\frac{1}{2}$ times as many pictures per foot as 35mm film; (2) it used reversal development that avoided the conventional negative-positive method requiring additional film material and costly printing stages; (3) it used mass processing techniques; and (4) the film size and apparatus encouraged international standardization with the useful feature of interchangeability. As a direct result of the wide acceptance of standard reversal films in both black-and-white and color for amateur motion pictures, a new industry has grown up employing many thousands of persons and home movies have been enjoyed by millions throughout the world.

Acknowledgments

The authors wish to acknowledge valuable suggestions for this historical paper received from James Card, G. A. Gillette, Jr., N. B. Green, H. A. Hartt, W. T. Hanson, Jr., V. J. Moyes, D. W. Rupert, R. S. Scott, W. C. Vaeth and A. K. Wittmer. We are especially grateful for the many constructive comments made by J. G. Capstaff, C. E. K. Mees and H. B. Tuttle.

Significant useful data were obtained from Charles Bass (Bass Camera Co.), Paul Busse (Thomas A. Edison Foundation, Inc.), L. Didiée (Kodak-Pathé), S. G. Rose (Victor Animatograph Corp.) and M. G. Townsley (Bell and Howell Co.).

Demonstration Reel of 16mm Pictures

Following the presentation of the paper a short 16mm motion picture (about 250 ft) was projected which included examples of amateur motion pictures that were taken shortly before and after the introduction of the Ciné-Kodak Process on January 8, 1923. The titles of these examples were as follows:

(1) *Early May 1920:* First reversal processed test film taken with first model of 16mm camera (duplicate print);

(2) *Several Test Films:* Taken with experimental 16mm camera during year 1920 (duplicate prints);

(3) *June 1921:* First amateur motion-picture story with planned and directed continuity taken with experimental 16-mm camera (duplicate print); and

(4) *1922–23 Family Scenes:* Taken with first production Model A Ciné-Kodak (original film).

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Perceptibility of Flutter in Speech and Music

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The results of subjective rankings of various speech and music selections containing various amounts and types of flutter are presented. These rankings are compared to the type of flutter and the results of flutter measurements using peak and rms indications and various flutter-rate weighting networks. The comparisons show that a meter using an rms indicating device and a flutter-rate weighting network will provide flutter measurements which are directly related to the obnoxious quality that the flutter imparts to music and speech.

SEVERAL YEARS AGO, the Society of Motion Picture Engineers proposed a standard method for measuring flutter.[1] The method proposed a flutter index based on empirical formulas derived from data on flutter threshold for pure tones at various flutter rates. These data were obtained in the Bell Telephone Laboratories and published previously in a paper by Albersheim and Mackenzie in this *Journal*.[2] Subsequently, this standard was presented for American Standards Association approval. The standard in its present form (fifth draft — not approved) includes the flutter index in the form of an appendix for information only since a good deal of controversy arose over the use of data obtained for pure tones as an indication of what effect flutter might have on speech and music.

Judging from the absence of precise information of the effect of flutter on speech and music, except for individual and sometimes contradictory opinions not supported by experimental data, there is little wonder that a controversy should arise over the use of a flutter index. A series of subjective experiments, connected with the development of an instrument for measuring flutter, has been conducted at the Material Laboratory for the Navy Bureau of Ships. The results of these experiments, to be discussed herein, indicate that not only can the information on pure tones be used to predict the effect of flutter on music programs but also that a weighting network can be incorporated in a flutter meter to provide a single reading of a flutter index which will bear a direct relation to its effect on music programs as judged by listeners. These experiments were found necessary because there was an almost complete void of information in the literature relative to the effect of flutter on speech or music programs. The only information available was concerned with the threshold of perceptibility of flutter in pure tones alone, and in this respect only one group of experiments at the Bell Telephone Laboratories, as previously mentioned, plus a few measurements of Lautenschlager[3] could be found. Fortunately, several experiments to find the differential pitch sensitivity of the ear were conducted in such a manner as to be relevant to the flutter problem. Of these, the only experiments having any degree of reliability are those reported by Shower and Biddulph[4] and by Knudsen.[5] An important group of experiments were conducted by H. Schecter at the Massachusetts Institute of Technology[6] but to date have not been published.

A preliminary study of the literature for information to guide the design of a realistic flutter measuring instrument resulted in the following conclusions:

(a) For frequencies up to about 500 cycles/sec the threshold of flutter perceptibility occurs for a constant frequency excursion, but above this frequency the threshold occurs at a constant per cent flutter except at the extremely high frequencies, 10,000 to 11,000 cycles, where a gradually increasing per cent flutter is required for perceptibility. It can be considered that a large portion of the energy of any speech or music program lies in the frequency range between 500 and 2,000 cycles/sec, where perceptibility is highest, and hence, the frequency response of a system would not be an important factor insofar as flutter perceptibility in program is concerned.

(b) Flutter perceptibility increases with sensation level up to a level of 40 db (ref. threshold). Above a level of 40 db the threshold of perceptibility is essentially constant. Since listening levels lower than 40 db are practically never used it could be considered that that level would not be an important factor.

(c) Although flutter perceptibility is slightly higher for double-earphone or bone conduction than for monaural hearing the difference is not practically significant. However, a loudspeaker in a reverberant auditorium produces much greater flutter perceptibility. The flutter thresholds found at Bell Telephone laboratories for listening in a live auditorium were about one-tenth as high as those reported by Shower and Biddulph for earphone listening. It is generally agreed that this effect results from standing wave patterns which produce amplitude as well as frequency modulation in a reverberant auditorium. If such is the case, the greater thresholds should only occur for pure tones or sustained notes. Since music and speech are continuously changing in both amplitude and frequency, standing wave patterns, except for rare instances, may not occur. On the other hand, there are those who believe that the direct and reflected waves may carry two tones, differing in frequency by the amount of the flutter excursion, to the listener's ears, resulting in beat notes of a low-frequency growling nature. If this is the case, then the flutter perceptibility should be much greater for those flutter rates whose period is equal to twice the time differential between the direct and reflected waves. The findings at Bell Telephone Laboratories do not indicate such a phenomenon but the information does not appear to be complete enough to warrant discarding this theory especially since the increasing perceptibility with increasing tone frequency (found constant with earphone listening for those tone frequencies considered) seems to support this concept. Certainly, here is an avenue for future investigation.

(d) The effect of flutter on tones appears to be experienced subjectively in three different ways. For flutter rates up to about 5 cycles/sec, the listener experiences a tone varying in pitch in accordance with the flutter amplitude and rate. For flutter rates between about 5 and 15 cycles/sec the listener seems to experience a change in loudness rather than frequency. Above a flutter rate of 15 cycles/sec the listener ceases to experience a changing pitch or loudness. Instead, he hears a low-frequency background tone which appears to coincide in pitch with the frequency of the flutter rate. The flutter perceptibility has been found to reach a maximum for a flutter rate of between 1 and 3 cycles/sec decreasing at flutter rates above and below almost as a direct or inverse function of flutter rate. Above flutter rates of about 80 cycles/sec Schecter shows that

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the perceptibility begins to increase, the amount of increase depending on the listening level and the tone frequency. For flutter rates above 100 cycles/sec Schecter has shown that the threshold masking curves can be predicted by considering the frequency-modulation sideband components of the fluttered wave at threshold. For earphone listening the flutter threshold at maximum perceptibility was found at 0.15% peak flutter. For listening in a reverberant auditorium the threshold was found at as little as one-tenth the percentage flutter obtained for earphone listening. There is some disagreement between the rate of decrease in flutter perceptibility above and below the flutter rates of maximum perceptibility but judging from the variation in the flutter waveshapes employed and the uncontrolled level and auditorium acoustics employed in some experiments these differences can be understood.

(e) Often flutter in equipment occurs in a very complex waveshape. Many believe that the effect of flutter is a function of the rms value of the flutter excursion. Others believe that its effect is better indicated by the peak excursion of the flutter. Further experimentation in this direction is warranted.

In order for the Laboratory to design or specify a meter for the realistic measurement of flutter, one which preferably would give one reading which would be directly related to the obnoxiousness imparted to speech or music, the following information was required: (a) whether information concerning the effect of flutter on tones could be applied to speech and music; (b) whether the indicating meter should be an rms, peak or other indicating device; and (c) whether the obnoxiousness imparted to speech and music would be affected by the acoustic characteristics of the listening space.

The experiments reported herein were designed primarily to answer these three questions. Absolute threshold values were not considered as a primary objective. In view of the fact that "vibrato," a form of flutter, is purposely added to tones by the musician to enhance quality, it was considered that music containing certain flutter could be found more pleasing. Hence, in most of the subjective experiments conducted, the flutter was varied from an amount that was judged to be imperceptible to an amount that was considered to have a maximum effect on programs. In addition, these experiments were particularly useful for determining whether a particular flutter meter was able to rank the various flutter types encountered in an order which agreed with a subjective ranking of the same flutter on the basis of its effect on program.

To cover every possible type of musical program that might be encountered would have been a hopeless task. On listening to various types of fluttered programs the following was indicated: (a) that certain types of musical instruments such as piano, brass, bells and chimes which ordinarily are not played with vibrato were more affected by flutter than were the string instruments such as violin, cello and guitars; (b) that, although flutter was more perceptible in certain instruments, on sustained tones the relative effect of flutter rate was about the same; (c) that for notes of short duration, flutter of low-frequency rate was not easily perceived but flutter of high-frequency rate, say above 10 cycles/sec, was equally perceptible regardless of tone duration; (d) that it was almost impossible to detract from the intelligibility of speech by introducing flutter; the low flutter rates up to at least 5% peak amplitude could not be detected in speech, but the high flutter rates were heard as a quivering in the speech; (As a point of interest, this quivering disappeared when white noise was introduced in the speech.) and (e) that the effect of flutter on male and female speech was similar.

As a result of these observations, it was decided to restrict experiments to a few types of program such as a pure 1000-cycles/sec tone, a sustained chord of eight tones, piano music, a symphonic orchestration and male speech. Musical programs were selected which contained both sustained and short notes from local station FM broadcasts or from high-quality test films.

Quality rankings of fluttered program were obtained by a subjective technique which was termed Listener Preference Test. This test is essentially a form of round robin quality comparison where, in view of the number of items being compared and the exhaustive number of individual comparisons required for a complete round robin, one of the items is selected as a standard to which all the items are compared. In the experiments reported herein comparisons were made in five categories on the basis of overall program quality. The judges were asked to state whether the item in question was much worse, worse, same, better or much better than the standard. Every attempt was made to carry out the experiments at random with respect to order of presentation of flutter variation, program selection and standard or unknown. A special category "don't know" was added in case the judge, because of inattentiveness or any other reason, was unable to make a judgment. In the experiments, at least 12 judges were used for each comparison. It is conceivable that there could be a large variation in the judges' categorization; for instance, for a particular difference in quality one judge might systematically categorize the comparison as "much better" whereas another judge would categorize the same comparison as only "better." This difference, in order to permit averaging all the judgments for each item to obtain a preference ranking score, was minimized by a statistical technique of quantification. The information was then subjected to an analysis of variance to determine the significant mean difference. In the work to be reported, the ranking scores themselves were used to plot listener preference against flutter measurements. This procedure could be questioned but, as will be indicated later, the listener-preference ranking scores are found to have a surprisingly linear relationship to flutter amplitude for each flutter rate investigated and hence indicate that the procedure is valid.

In a preliminary experiment the realistic approach was pursued using the sound sections of nine different motion-picture projectors. Listener preference rankings were obtained for double-earphone listening with and without inclusion of a 2-sec echo chamber for various program selections from high-quality test film. The preference ranking scores were compared with measurements of frequency response, signal-to-noise ratio, harmonic distortion and intermodulation distortion at a medium level, peak-to-peak flutter and a flutter index calculated from flutter threshold for a 1000-cycles/sec tone. The ranking scores were found to be related to the intermodulation distortion and flutter index measurements. The relationship was considerably improved by converting the IM distortion and flutter index measurements to a combination "preference index" by questionable means. The results of the preliminary run indicated the following: (a) that in order to obtain any information on flutter all other distortions should be confined to an insignificantly low value; (b) that there is a possibility of obtaining a combination quality index for all types of distortion in an audio system but continued investigation toward this object was beyond the scope of the project; and (c) that the preference rankings obtained for direct earphone listening were similar to those obtained when an echo chamber was used. However, there may have been a difference in the actual threshold of flutter perceptibility which was not revealed.

In a second experiment eighteen types of flutter were obtained by modifying the drive mechanisms of three tape recorders. Other distortion was held at a constant low figure by using a separate high-quality reproducing system. Fifteen-sec selections of piano, cello, slow speech and relatively fast speech programs with the various flutters introduced were recorded on a high-quality tape recorder and spliced together in a manner which would allow comparisons of each type of flutter with one of the eighteen selected

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as a standard. Listener-preference rankings for the eighteen flutter variations were obtained for earphone listening with and without reverberation introduced by means of an echo chamber. These rankings were then compared against measurements of peak-to-peak flutter and a flutter index measured on a flutter meter which was modified to give an rms meter reading and to include a weighting network based on the variation of flutter threshold with flutter rate for a 1000-cycles/sec tone. The results as shown in Table I indicate that there is no significant difference between ranking scores obtained with and without approximately 2 sec of reverberation. It is not meant to suggest that flutter is not more perceptible in a reverberant room. The data merely indicate that, if one particular fluttered program sounds worse than another particular fluttered program in a nonreverberant room, they will compare similarly in a reverberant room.

The data of Table I when plotted against peak-to-peak flutter and the flutter index will indicate that the flutter index as measured with the modified meter has a better relationship to listener preference than does the peak-to-peak flutter measurement. It would appear that the modifications to the flutter meter made in this experiment are a step in the right direction but a better relationship was desired. The complex flutter waveshapes employed in this experiment led to difficulty when it was attempted to assess whether most of the improvement in flutter measurement could be attributed to either the weighting network or the rms Indicator.

The next experiment was conducted using only sinusoidal flutter. Every possible combination of flutter having peak amplitudes of ½, 1, 2, 3, 4 and 5% and flutter rates of ½, 1, 2, 3, 4 and 5 cycles/sec were introduced in the following types of program: (a) a 1000-cycles/sec tone; (b) a major "C" chord consisting of tones C_2 E_2 G_2 E_5 G_5 and C_6; (c) a piano selection of "Love Walked In"; (d) symphony orchestra; and (e) speech of a male news commentator. A flutter generator was borrowed from H. Schecter at the Massachusetts Institute of Technology for the purpose. This flutter generator shown in Fig. 1 was essentially a magnetic-tape reproducing unit which introduced flutter by cyclicly changing the position of the playback head in relation to the tape drive by means of a "Scotch Yoke." The amplitude of the head excursion was adjustable through a vernier adjustment as shown in the insert of Fig. 1.

Recordings of 10-sec passages of these fluttered programs were then made and spliced together to permit a listener-preference test. Listener-preference ranking scores were obtained for loudspeaker listening in a relatively dead listening room. The flutter generator unfortunately had an inherent 4-cycles/sec flutter of about 0.2% rms amplitude. The frequency response of the overall recording and reproducing processes was limited only by the loudspeaker and included frequencies to 13,000 cycles/sec. Nonlinear distortion was held below 1.5% harmonic content and signal-to-noise ratio was greater than 45 db.

Table I. Listener-Preference Ranking Scores for Eighteen Flutter Types.

Flutter variation no.	Peak-to-peak flutter %	Flutter index no.	Listener-preference ranking scores: Music, No reverb.	Music, With reverb.	Fast speech, No reverb	Fast speech, With reverb.	Slow speech, No reverb.	Slow speech, With reverb.
1	0.65	65	28	27	42.8	51.7	52.8	54.5
2	1.0	85	29	18	38.3	37.2	60	61.2
3	0.8	80	36	31	48.4	42.8	34.9	40.0
4	1.5	100	37	35	44.5	43.9	43.4	33.4
5	1.8	160	42	48	36.1	47.3	34.9	48.4
6	3.4	315	61	51	51.7	66.2	42.8	34.9
7	3.0	300	77	67	42.3	47.8	31.5	46.2
8	2.4	800	43	61	77.3	94.5	91.7	93.4
9	3.6	540	33	16	41.7	39.4	32.2	31.7
10	1.9	160	35	26	46.2	37.2	46.2	57.8
11	5.3	400	43.8	55.5	42.8	43.9	47.3	35.0
12	5.8	500	77.3	89	49.5	43.4	52.8	35.0
13	6.8	420	36.7	57	45	40.6	44	43
14	7.1	880	74	75	92	82	93	93
15	8.4	790	71	69	54	43	60	53
16	7.0	590	58	61	64	47	43	51
17	7.6	420	85	78	43	49	48	48
18	8.8	1000	83	83	95	92	93	90
Sig. Mean Diff.			17	17	17	18	16	18

Table II. Listener-Preference Ranking Scores for Tone, Chord, Piano and Orchestra.

Flutter Rate cycles/sec	Flutter Amp. % peak	Listener preference ranking score: 1000-cycles/sec tone	Chord	Orchestra	Piano	Average
½	½	9	19	23	24	19
½	1	42	33	30	36	35
½	2	70	52	62	71	64
½	3	83	74	96	89	85
½	4	87	96	96	100	95
½	5	100	86	96	92	93
1	½	20	18	21	24	21
1	1	45	40	39	47	43
1	2	63	78	63	60	66
1	3	91	96	96	78	90
1	4	83	87	96	93	90
1	5	60	91	100	100	88
2	½	14	15	20	19	17
2	1	52	60	39	37	47
2	2	96	85	96	89	91
2	3	83	83	92	100	89
2	4	89	100	100	100	97
2	5	87	100	96	100	96
3	½	32	22	21	18	23
3	1	66	87	55	49	64
3	2	96	70	70	53	72
3	3	86	91	93	100	92
3	4	96	91	100	93	95
3	5	95	100	96	92	96
4	½	29	38	21	24	28
4	1	50	87	45	42	56
4	2	84	96	85	97	90
4	3	100	91	100	82	93
4	4	74	100	100	100	93
4	5	95	91	100	100	96
5	½	15	14	22	21	18
5	1	36	39	22	32	32
5	2	74	78	85	64	75
5	3	70	96	89	96	88
5	4	77	86	100	100	91
5	5	90	100	96	100	96
	Sig. mean diff.	16	14	12	13	

NOTE: Lower listener-preference ranking scores associated with least degradation in quality.

In Fig. 2, the average ranking scores for all the programs are plotted against flutter amplitude. The relatively smooth relationship between listener preference and flutter amplitude at each flutter rate indicates the validity of the listener-preference ranking technique. For each flutter rate a straight line can be drawn through the data at the lower flutter amplitudes. The slope of these lines can be used to calculate the relative flutter perceptibility thresholds at each flutter rate. The threshold values obtained in this manner, for an absolute threshold at 3 cycles/sec equivalent to the threshold reported by Schecter for a 1000-cycles/sec tone are shown in Table III.

Except for the flutter rate of ½ cycle/sec the relative thresholds for three experiments are essentially similar.

A flutter index was calculated for each flutter variation by dividing the flutter amplitude by the appropriate Material Laboratory threshold flutter at each flutter rate.

Table III. Flutter-Perceptibility Thresholds.

Flutter rate cycles/sec	Flutter-perceptibility threshold peak-to-peak %: Shower and Biddulph	Harry Schecter	Material Laboratory
0.5	0.5 (by extrapolating)	1.4	0.68
1	0.33	0.6	0.64
2	0.28	0.36	0.45
3	0.29	0.35	0.35
4	0.45	0.38	0.43
5	0.7	0.42	0.64

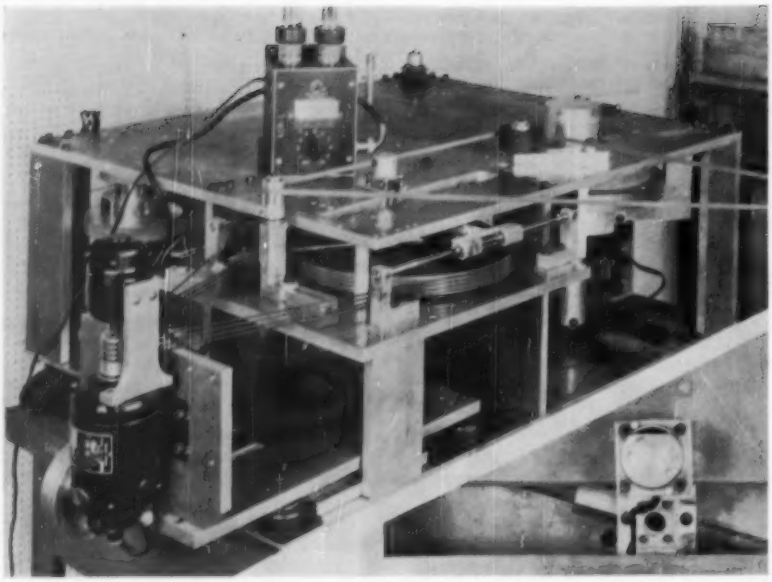

Fig. 1. The M.I.T. Acoustics Laboratory Flutter Generator. Inset shows Scotch Yoke assembly.

In Fig. 3 the average listener-preference ranking scores are shown plotted against the calculated flutter index to show the improvement in relationship over that obtained for per cent peak flutter. Thus, for flutter rates from ½ to 5 cycles/sec, a weighting curve dictated by a factor of the relative flutter thresholds could be employed in a realistic flutter-measuring instrument for program other than speech.

For flutter rates above 5 cycles/sec a subjective technique involving amplitude adjustment was employed to find flutter-perceptibility thresholds for the same five programs used in the previous experiment. Flutter was introduced by means of the flutter generator shown in Fig. 4 which was also a magnetic-tape reproducing unit where relative motion between the playback head and tape drive was produced by mounting the head on a plexiglass tube which was cemented to the cone of a loudspeaker. The frequency response in these experiments was limited by the PDR 10 earphones used by the judges to a range essentially 30 to 8000 cycles/sec. Nonlinear distortion was again held to less than 1% harmonic content and signal-to-noise level maintained at better than 45 db. Inherent flutter was about 0.2% rms at approximately 4 cycles/sec.

The Flutter perceptibility thresholds for each program are shown in Figs. 5–9. In spite of variation between several trials for an individual judge and between judges, the average thresholds for a group of judges when plotted against flutter rate indicate fairly smooth curves as shown in Figs. 5 through 9 which do not vary appreciably (see Fig. 10) between the five program selections employed in the experiments. The index values found in the previous group of experiments are used to complete the curve below 5 cycles/sec. In Fig. 5 the average thresholds obtained for tone are compared against those obtained by several other experimenters. All experimenters show approximately the same shaped curve with a minimum threshold at a flutter rate of approximately 2 cycles/sec, however auditorium reverberation, as shown by the data obtained at Bell Telephone Laboratories and possibly Lautenschlager, greatly lowers the threshold. The higher thresholds obtained from the experiments conducted at the Material Laboratory may be due to the inherent flutter in the flutter generator or nonlinear distortion which tended to hide the true threshold. The break in the smooth curve at flutter rates of 50 and 75 cycles/sec was probably due to an inherent 60-cycles/sec hum in the equipment which resulted in subjective beating.

The main purpose of the experiment has been fulfilled, however, by showing that at least for the types of program employed, the effect of flutter on music program is essentially the same as its effect on a 1000-cycles/sec tone. The effect on speech is the same as tone for flutter rates above 5 cycles/sec. Below 5 cycles/sec, flutter as high as 4% rms could not be detected. The difference between threshold obtained in these experiments and those reported by other experimenters led to the suspicion that the judges employed reacted differently to flutter than did those employed by previous experimenters. To settle this question, Schecter's experiment for 1000-cycles/sec tone, 60-db sensation level and using an electronically warbled oscillator were duplicated using three of the judges used in the previous experiments. The average thresholds obtained as indicated in Fig. 11 are in general agreement with Schecter's data.

A limited experiment was conducted to determine whether a realistic flutter meter should measure the peak or rms value of flutter excursion. In this experiment, a 1000-cycles/sec oscillator tone was electronically frequency-modulated with a 2-cycles/sec square wave of various degrees of unbalance resulting essentially in a switching between two adjustable frequency tones at a rate of 2 cycles/sec in such a manner that the duration of one tone could be adjusted from 10 to 250 msec, while the other tone was present for the remainder of the 500-msec period. Perceptibility thresholds were obtained for various degrees of unbalance. The results are shown in Fig. 12

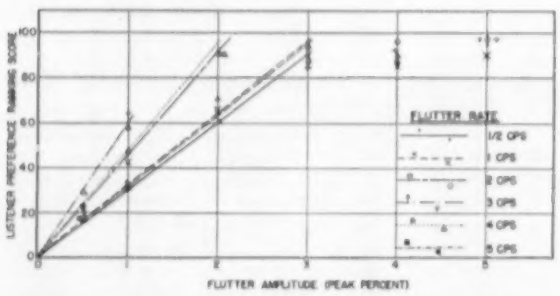

Fig. 2. Average listener-preference ranking scores for tone, chord, piano and orchestra vs. flutter amplitude.

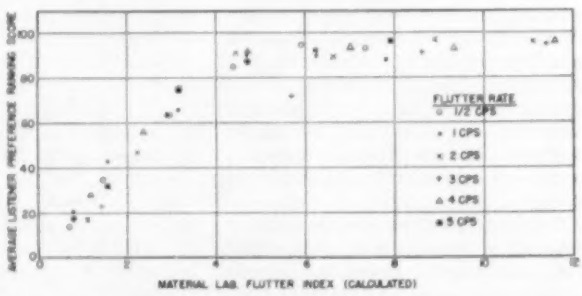

Fig. 3. Average listener-preference ranking scores for tone, chord, piano and orchestra vs. Material Laboratory flutter index.

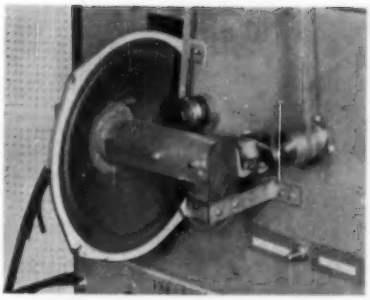

Fig. 4. Material Laboratory Flutter Generator.

to agree well with the threshold curve calculated under the assumption that the relative thresholds were an inverse function of the rms content ("o" reference level is equal to the average level) of the modulating wave. These results indicate that the flutter meter should be designed to have an rms indicating meter.

The results of these experiments indicate:

(a) That the subjective effect of flutter on the chord, piano and orchestra selections is the same as that noted for a 1000-cycles/sec tone.

(b) That the relative effect of flutter on program is not changed by introducing reverberation.

(c) That a flutter-rate weighting network dictated by flutter perceptibility thresholds for a 1000-cycles/sec tone coupled with a well-damped rms indicating meter can be used in conjunction with a flutter meter to provide a realistic measurement of flutter.

(d) There is a possibility that all system distortion might be expressed in terms of an index and combined to form a single

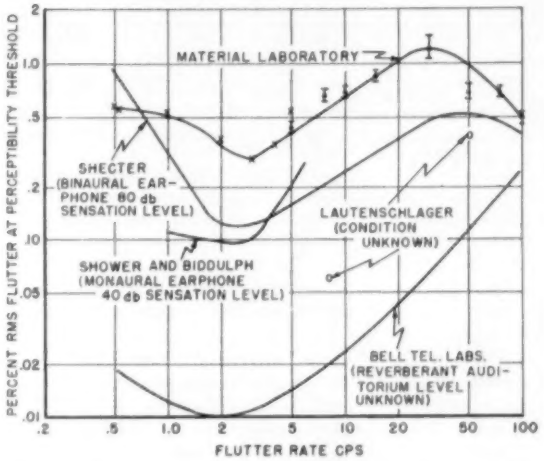

Fig. 5. Flutter perceptibility threshold for 1000-cycles/sec tone vs. flutter rate: Φ = average 33 observations, 11 judges, with 95% confidence limit, 90-db sensation level, double-earphone listening with inherent flutter of 0.2% at 4 cycles/sec and harmonic distortion of 1%; x = determined previously from listener preference ranking scores.

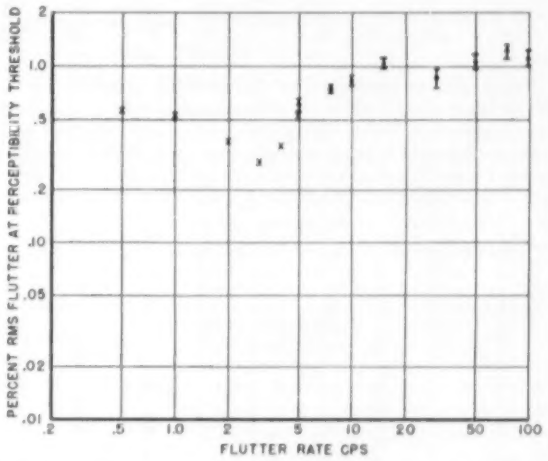

Fig. 6. Flutter perceptibility threshold for chord vs. flutter rate: Φ = average 33 observations, 11 judges, with 95% confidence limit, 90-db level, double-earphone listening with inherent flutter of 0.2% at 4 cycles/sec and harmonic distortion of 1%; x = from listener-preference ranking scores.

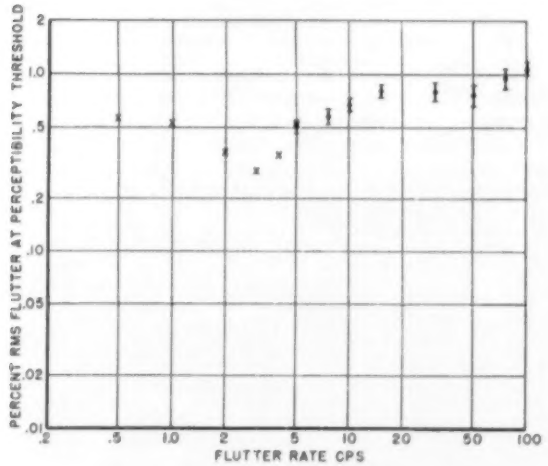

Fig. 7. Flutter perceptibility threshold for piano program vs. flutter rate: Φ = average 33 observations, 11 judges, with 95% confidence limit, 90 db level, double-earphone listening with inherent flutter of 0.2% at 4 cycles/sec and harmonic distortion of 1%; x = from listener preference ranking scores.

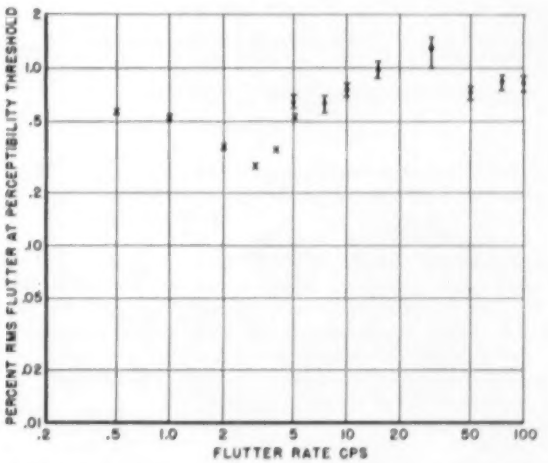

Fig. 8. Flutter perceptibility threshold for symphony orchestra vs. flutter rate: Φ = average 15 observations, 3 judges, with 95% confidence limit, 90-db level, double-earphone listening with inherent flutter of 0.2% at 4 cycles/sec and harmonic distortion of 1%; x = from listener preference ranking scores.

A Light Meter for Printer Control

By A. J. SANT, M. C. GODDARD and O. E. MILLER

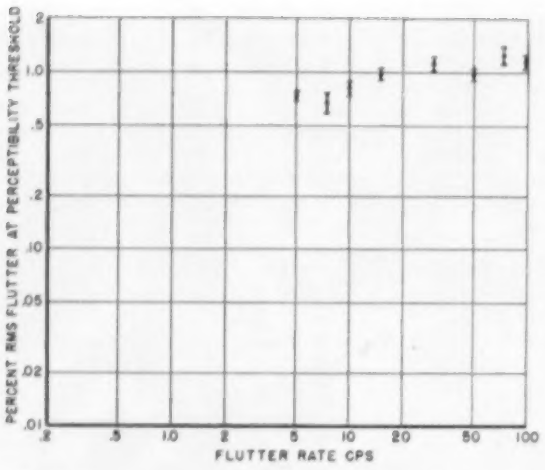

Fig. 9. Flutter perceptibility threshold for male speech vs. flutter rate: Φ = average 15 observations, 3 judges, with 95% confidence limit, 90-db level, double-earphone listening with inherent flutter of 0.2% at 4 cycles/sec and harmonic distortion of 1%.

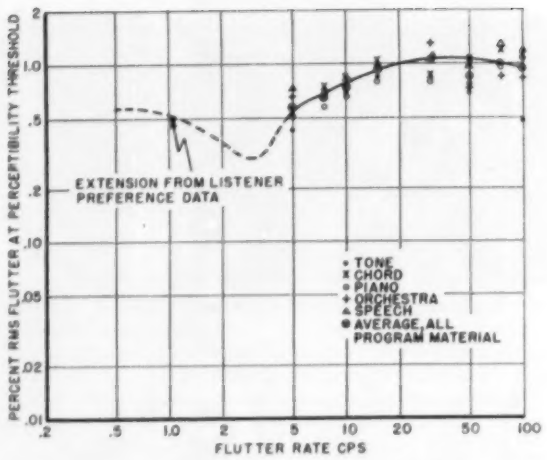

Fig. 10. Average flutter perceptibility thresholds for all program material vs. flutter rate: 90-db level, double-earphone listening, with inherent flutter of 0.2% at 4 cycles/sec and harmonic distortion of 1%.

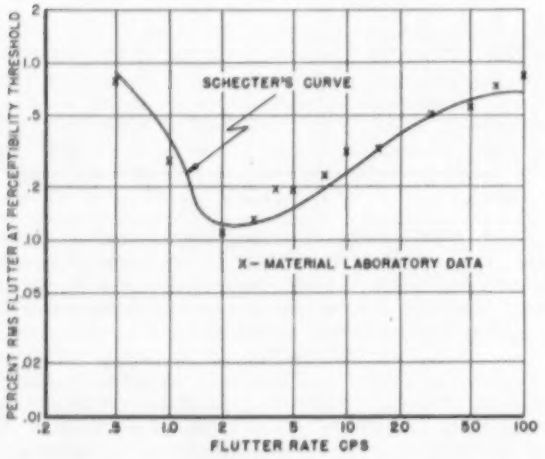

Fig. 11. Flutter perceptibility thresholds for 1000-cycles/sec oscillator tones vs. flutter rate: x = average of 11 observations, 3 judges, double-earphone listening, 60-db sensation level.

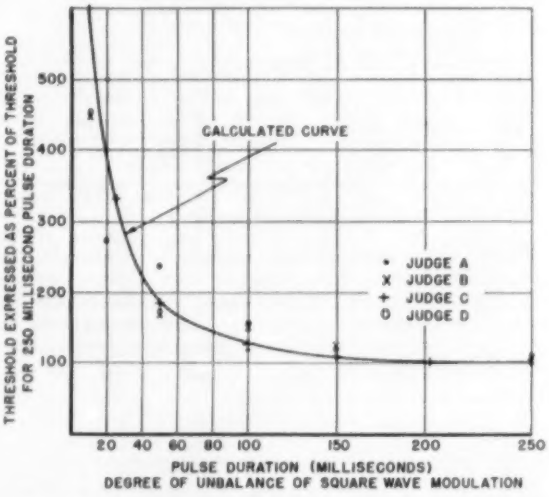

Fig. 12. Comparison of calculated and experimental perceptibility thresholds of unbalanced square wave frequency modulation: calculations on basis of threshold = inverse function of rms content of wave, where "o" reference level = average level; experimental data taken for 1000-cycles/sec oscillator tone, 90-db sensation level, double-earphone listening.

quality index which would be a realistic indication of the system's merit.

In experiments now in progress at the Laboratory, listener-preference rankings of music and speech program with 100 flutter variations introduced and flutter index measurements of each flutter variation are being compared to show that a flutter index measurement is a realistic means of assessing the flutter content of equipment.

Acknowledgment

The loan of the Acoustics Laboratory M.I.T. Flutter Generator and comments made by H. Schecter during the planning stages of the project are sincerely appreciated.

References

1. SMPE Committee on Sound, "Proposed Standard Specifications for Flutter or Wow as Related in Sound Records," *Jour. SMPE 49:* 147–159, Nov. 1947.
2. W. J. Albersheim and D. Mackenzie, "Analysis of sound film devices," *Jour. SMPE 37:* 452, Nov. 1941.
3. F. Lautenschlager, "Über die subjective Wahrnehmbarkeitzgrenze und eine Methode zur objektiven Bestimmung von Filmtransportstörungen beim Tonfilm," *Elek. Nacht. Tech., 11:* 409–413, Dec. 1934.
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5. V. O. Knudsen, "Sensibility of the ear to small differences of intensity and frequency," *Phys. Rev. 21:* 84, 1923.
6. H. Schecter, "Perceptibility of frequency modulation in pure tones," Doctorate Thesis, Massachusetts Institute of Technology, 1949.

Editorial Note: Following this paper at the Convention there was extensive discussion which has been impossible to get circulated promptly; therefore the abstract of the oral comments, after clearance by the discussers, will be published later.

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A Light Meter for Printer Control

By A. J. SANT, M. C. GODDARD and O. E. MILLER

Because of the increased need for the control of motion-picture printers used for printing color films, a simple barrier-cell type of light meter was designed for use on release printers. The meter has very good stability and linearity of response. Its sensitivity is very adequate for the intensity levels encountered in release printers. The probe unit contains a filter magazine that permits rapid reading through red, green and blue filters. It was designed to give photocell response which closely approximates the responses of the three sensitive layers of Eastman Color Print Film, Type 5382.

THE INCREASED USE of color print films in motion-picture positive release printing necessitates a more accurate control of the intensity and color balance of the printer light in order to maintain the necessary quality and uniformity in the release prints. Good laboratory practice requires a convenient and reliable light meter with which the intensity and color balance of the printer light can be measured readily and with the necessary precision. Aex[1] previously described a light meter for the control of printers used for printing Kodachrome duplicating films. His meter uses a barrier cell connected to a galvanometer. Successive readings are made through red, green and blue filters to detect changes in intensity in the three principal spectral bands to which the corresponding layers of the film are sensitive.

While Aex's meter is quite adequate for control in printing Kodachrome, Horton[2] found it not precise enough for the control of printers used for printing high gamma materials such as Eastman Color Print Film, Type 5382. A meter described by Horton makes use of the Densichron Photometer.* Three readings are taken through red, green and blue "analyzing" filters. While some laboratories are making use of a Densichron meter, it was considered that a selenium barrier-cell might offer some advantages in simplicity, stability and linearity, if operated under favorable conditions such that the effects of fatigue and temperature variations were minimized. The sensitivity is quite adequate for measurement of the high intensity levels used in color release printers. Temperature variations should not be a serious problem in the motion-picture laboratory. It was with these thoughts in mind that the meter described here was designed.

The principal features of a satisfactory meter for printer control may be listed briefly, as follows:

1. Adequate sensitivity.
2. Stability of the zero and of the response to a given light intensity.
3. Good scale linearity.
4. Reasonable freedom from the effects of fatigue and temperature variations.
5. Adequate precision for the necessary control.
6. Spectral sensitivity distributions similar to those of the sensitive layers of the print film.
7. Maximum simplicity, ruggedness and portability.
8. Means for mounting at the printer aperture in a precisely reproducible position.

[1] P. S. Aex, "A photoelectric method for determining color balance of 16 mm Kodachrome duplicating printers," *Jour. SMPE*, 34: 425–430, Nov. 1947.

[2] C. A. Horton, "Printer control in color printing," *Jour. SMPTE*, 58: 239–244, Mar. 1952.

Presented on October 22, 1954, at the Society's Convention at Los Angeles, by A. J. Sant, M. C. Goddard and O. E. Miller (who read the paper), Color Technology Div., Kodak Park Works, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on December 2, 1954.)

* Manufactured by the Welch Scientific Co.

Description of the Instrument

The meter to be described satisfies the above mentioned design requirements. Basically it consists of a barrier cell, Type PV-1, manufactured by the General Electric Co., and a Weston, Model 622, microammeter with a range of 50 μa and a resistance of about 90 ohms. A low load resistance is important because it results in a linear cell response and minimizes both fatigue and temperature effects. The cell is mounted in the body of a metal probe which contains a circular filter magazine. Figure 1 shows the probe and microammeter. Also shown is a mounting bracket for precise location of the probe on a Model D Bell & Howell Printer.

The design of the probe unit is more easily visualized by referring to the exploded schematic view, Fig. 2. In the filter magazine are the three filters for reading the red, green and blue components of the printer light. The fourth position carries an opaque disk to protect the cell from ambient light when not in use. This may be removed for "white" light readings. In the front face of the probe is mounted a coverglass with a dichroic* infrared reflective coating. This serves three purposes, viz., it keeps out dust, eliminates the unwanted infrared response of the cell, and reduces the heating of the cell when exposed to high intensity tungsten radiation.

The cutout section at the side of the probe exposes the knurled edge of the filter wheel which rotates easily about its

* Bausch & Lomb Optical Co., Experimental Coating No. 169.

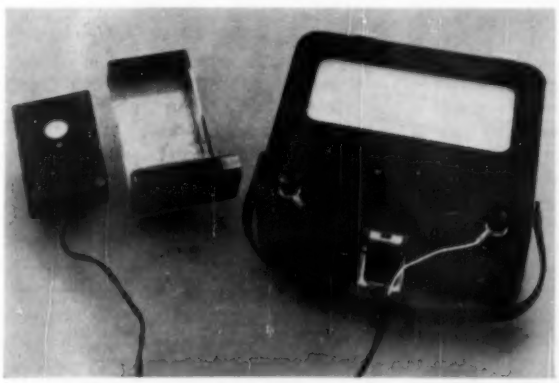

Fig. 1. Probe, mounting bracket and microammeter.

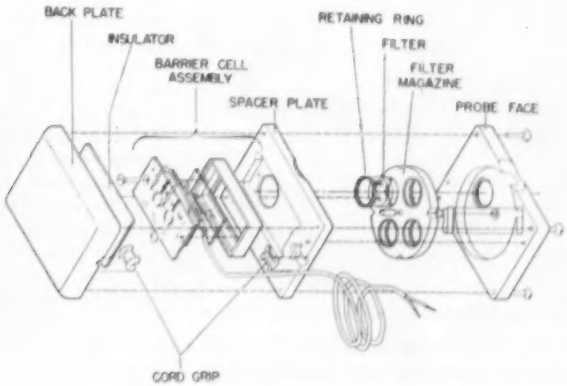

Fig. 2. Schematic of probe unit.

Figure 5 shows the method of mounting the probe in front of the printer

Linearity is good so long as the resistance of the meter does not exceed 100 ohms

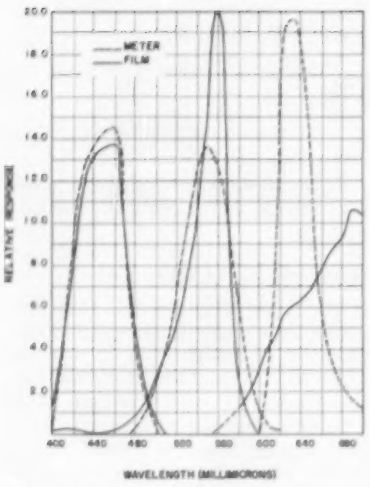

Fig. 3. Calculated spectral responses of the film and the filtered photocell.

own center. The filters are automatically and reproducibly centered in the probe window by means of a spring-loaded roller which engages notches in the edge of the disk. Color coded index marks in the edge of the wheel give a visible indication of which filter is in front of the window. The sides of the probe are machined and may be used as reference surfaces for precise mounting on a printer.

Spectral Responses

The filters were selected to give spectral responses reasonably similar to those of the three sensitive layers of Eastman Color Print Film, Type 5382. The spectral responses of photocell and film were calculated from available data. The cell sensitivity data were obtained from Bulletin GEA-2467C published by the General Electric Co. The spectral sensitivity data for the print film were furnished by W. R. J. Brown of the Kodak Research Laboratories. The spectral energy distribution was assumed to be that of a blackbody of 3000 K modified by Pittsburg No. 2043 heat absorbing glass in a thickness of 4 mm and two thicknesses of Wratten Filter 2B.

First the spectral transmittance values of a set of ideal filters were calculated such that the three spectral responses of the meter would exactly match those of the color print film. This was done by dividing the film sensitivity by the sensitivity of the photocell at the same wavelength. Next, three Wratten filters were selected that were considered to be a sufficiently close approximation to the ideal filters. They are Wratten filters 29, 53 and 47B. In addition to these, Wratten No. 96 neutral filters of suitable densities were added in order to equalize roughly the red, green and blue responses of the meter to the printer light.

The meter and film responses were then computed at discrete wavelength intervals as the product of the energy, E, the transmittance, T, and the sensitivity, S, at each wavelength. Filter transmittance data were obtained from the Wratten Filter Data Booklet.

For calculating the film responses, the energy distribution of the printer was further weighted for the effect of the absorption of the colored couplers in Eastman Color Negative Film, Type 5248. The graph in Fig. 3 shows a comparison of the calculated spectral responses of the film and of the filtered photocell, normalized for equal areas under the individual curves.

Fortunately the fit does not have to be too exact, since dye absorptions and sensitivity bands are rather broad and the responses are integrated over the spectrum. In view of this the fit was considered very satisfactory.

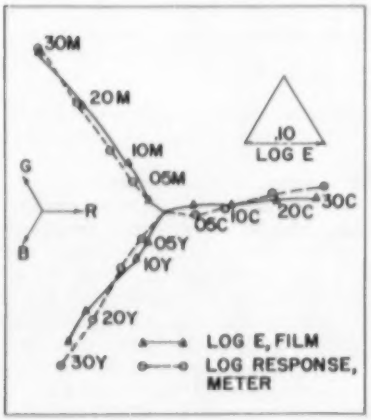

Fig. 4. Changes in exposure and color balance of the film layers compared with changes in the logarithms of meter readings.

Performance Tests

The instrument has been given a number of tests to determine its performance with respect to the attributes considered important for printer control. Stability and precision were checked by making replicate readings with a standard tungsten source on several different days distributed over a period of several weeks. Day to day variability was no greater than the variability within a single day. Variance analysis of sets of duplicate readings made on a Bell & Howell printer with two similar meters over a period of several days indicates that the variability of the meter readings was less than the variability of the source. The total variability may be expressed by a 3 σ value of .01 log E. This is well within the tolerance of .02 log E in color balance mentioned by Horton as acceptable for high gamma color printing.

In a linearity test over a range of 0–200 μa there were no departures from a straight line in excess of 0.5% of full scale. The small variations about the least squares straight line were completely random.

The fatigue effect was measured at a current of 200 μa, which is four times full scale on the meter. The change in cell output was less than 1% after a 30-sec exposure. Recovery of the cell was complete after one minute in the dark. At the 50-μa level the effect of fatigue is scarcely detectable.

In order to check the correspondence between cell response and film response, a sensitometric test was performed on a Model D Bell & Howell printer. The color balance was varied by means of Kodak Color Compensating Filters of the cyan, magenta, and yellow series. Four filters, 05, 10, 20, and 30, of each series were used. For each color balance condition, red, green and blue readings were taken on the meter and a photographic silver gray scale was then printed onto Eastman Color Print Film. In making the prints the printer light was filtered by a fixed out piece of Eastman Color Negative Film, Type 5248. Differences in log E indicated the changes in exposure and color balance in the three layers of the print film due to changes in the color compensating filters. These were compared with the corresponding changes in the logarithms of the meter readings. They are shown by the dashed lines in the trilinear graph, Fig. 4, in which changes in color balance are shown as density changes in the three directions on the triangular plot. Shown in the same graph by solid lines are the corresponding changes in the color balance of the color print film.

Considering the many sources of error in a test of this type the agreement is considered excellent.

The Use of the Meter for Printer Control

This meter has been used for nearly a year for the control of a Model D Bell & Howell printer in the Color Technology Div. of Kodak Park.

This printer is used in making prints on Eastman Color Print Film, Type 5382, for the practical evaluation of the quality of Color Negative, Color Internegative and Color Print Film coatings and for product and process improvement tests. Routine meter readings are made each time the printer is set up for making prints. Within this period of use many adjustments have been required due to changes in film characteristics, lamp aging, lamp replacements, breakage of glass filters and cleaning of the optics. In all cases, variations in intensity and color balance have been controlled well within the range detectable in the prints. Although the meter has been checked with a standard source at frequent intervals, there has been no significant change in its response. Its operation has been completely free of troubles of any kind.

Figure 5 shows the method of mounting the probe in front of the printer aperture. A mounting bracket that carries the probe unit is substituted for the shoe and gate assembly which is easily removed for the purpose of checking the printer light. The probe face rests solidly against the body casting. With this arrangement no alteration of the printer was necessary. The position of the probe at the aperture is precisely reproducible. Other methods of mounting are possible so long as the position is reproducible and enough of the light beam is received on the photocell to insure adequate sensitivity.

The meter has more than adequate sensitivity for this printer, which uses a 300-w lamp and prints at a speed of 60 ft/min. It gives about three-fourths full scale reading at step 18. With only a slight loss in precision the less expensive Weston Model 430, 0–30, microammeter could be substituted for the Model 622. Linearity is good so long as the resistance of the meter does not exceed 100 ohms. The sensitivity range can be extended by the use of a multirange meter, although the light change on the printer is a very convenient means for adjustment of the scale readings so as to take full advantage of the sensitivity and accuracy of the output meter.

Summary

A simple light meter has been described which was designed for the control of intensity and color balance of motion-picture release printers. It has adequate sensitivity, stability and linearity for the control of printers used to print Eastman Color Print Film, Type 5382. The red, green and blue responses of the meter are well matched to the responses of the Color Print film. Fatigue and temperature effects are negligible. During one year of operation it has been proven entirely dependable for printer control.

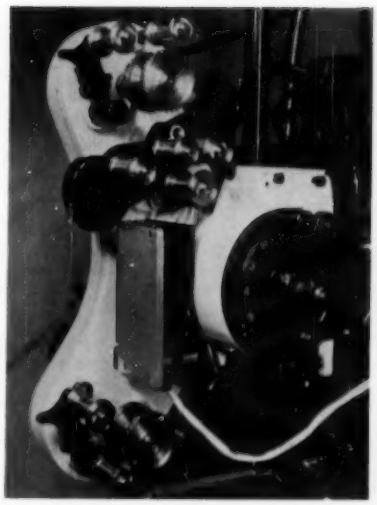

Fig. 5. Probe mounted in front of printer aperture.

High-Speed Photography Notes

Errata and Lacunae — High-Speed Photography Reprint Volumes Contents and Indexes

Two of the First International Symposium papers were inexplicably omitted from High-Speed Photography Vol. 5. These are:

Richard O. Painter, "Techniques for effective high-speed photography and analysis," *Jour. SMPTE, 58:* 373–384, May 1952.

Ernest C. Barkofsky, "Multiple-image silhouette photography for NOTS Aeroballistics Laboratory," *Jour. SMPTE, 58:* 480–486, June 1952.

Omitted from the Cumulative Index of Authors were:

Garvin, Elsie L., Bibliography on High-Speed Photography Including Schlieren and Cathode-Ray Oscillograph Photography, vol. 3, pp. 138–156.

———, vol. 5, pp. 276–284.

Overlooked in the "Bibliography on High-Speed Photography" in the December 1953 Journal and in High-Speed Photography Vol. 5 was:

"Errata" — J. H. Waddell, "Design of rotating prisms for high-speed cameras," Jour. SMPE, vol. 53, pp. 496–501, Nov. 1949, *see Jour. SMPTE, 57:* 82–83, July 1951.

High-Speed Photography Volumes Available

From the Society of Motion Picture and Television Engineers, 55 West 42d St., New York 36, N. Y., with a 10% discount to Society members:

High-Speed Photography, Reprint Vol. 4, 162 pp., original articles having appeared in the *Journal* between February 1951 and June 1952. $2.50

High-Speed Photography, Reprint Vol. 5, 364 pp., the articles having in the main been presented at the *First International Symposium* held at Washington in 1952, reprinted from the *Journal* between July 1952 and February 1954. $4.50

Information is available from the SMPTE or from Ing. Ppal. P. Naslin, L.C.A. Fort de Montrouge, Arcueil (Seine), France, about:

2d International Symposium on High-Speed Photography and Cinematography which will be published by the AFITC and will cost between 2000 and 3000 francs, depending on the number of orders. Each paper will be published in the language chosen by the author. Summaries and figure titles will be printed in the three languages — French, English and German. Upon inquiry, there will be sent a 6-page folder which lists all the papers, authors and affiliations.

Separation Process for Additive Color Motion-Picture Photography on Black-and-White Film

By LAWRENCE F. BRUNSWICK

A new process, particularly applicable to the color-television field, is described. This equipment makes possible photography in full additive color on ordinary black-and-white film when fitted to the typical studio motion-picture camera. Its relationship to the needs of the color-television industry is considered. Characteristics concerning economy of operation, set-lighting requirements and angle of view are discussed. Related projection and printing equipments and techniques are described.

THE RESEARCH PROGRAM that resulted in the invention and subsequent development of the Colorvision system of additive color motion pictures was based on the anticipated needs of the color-television industry, as visualized in the perspective of early 1950 when the project was commenced.

At that time we recognized that regardless of the final electronic means used to achieve a practical color-television system, certain basic requirements would, in all probability, remain constant.

Technically, it was apparent that the information carried in three separation images would be completely adequate for any method of color-television transmission. In fact, direct separations would make possible higher-quality reproduction due to the avoidance of one generation of color in the reproduction chain.

It also appeared obvious that the economic aspects of a color photographic process using black-and-white film would be a favorable element.

A very significant factor in favor of the additive system was the universal availability, simplicity and rapidity of black-and-white processing facilities, thereby avoiding the bottleneck of slow processing associated with subtractive color material. It also appeared that if rush color kinescopes were to be made commercially practicable, a simplified rapid process was imperative.

Photographing color additively offered certain incidental advantages beyond those of economy, speed and color quality. Because black-and-white negative material is used in the camera, hand tests may be run on location in the normal black-and-white manner. Also, black-and-white raw stock and processed film are not subject to deterioration to the same extent as are color materials. In addition, special processing techniques such as latensification, hypersensitization and high energy development, are applicable with relative ease.

Therefore, the additive method of color photography, with its inherently high-quality reproduction, was selected as being the most logical method for use with color television.

It then became apparent that a practical solution to the problems associated with additive color motion-picture photography which would fulfill the economic and technical requirements of color television entailed an optical system embracing the following:

1. The formation of three geometrically identical images, within reasonable tolerances, in the 35mm frame.
2. The formation of three images of such spectral characteristics as to approximate very closely the characteristics of the Kodak Wratten filters, Nos. 25, 58 and 47B.
3. Set-lighting requirements as close as possible to normal black-and-white levels.
4. Flexibility regarding angle of view, comparable to normal black-and-white equipment.
5. Absolute freedom from parallax, either spatial or time.
6. Simplicity of operation by regular personnel.
7. Physical characteristics to conform with typical motion-picture cameras.

The fulfillment of these requirements obviously involved a radical departure from prior optical systems.

Broadly speaking, the Colorvision optical system is a beam splitter with a relative aperture clearly in excess of $f/2$. The light enters the system through a single entrance pupil, is then spectrally divided by means of multilayer interference filters and channeled to the film plane where three geometrically similar, but spectrally separated, images are formed as shown in Fig. 1. Incidentally, each Colorvision image has an area 40% greater than the normal 16mm frame.

The requirements referred to above are correlated to the Colorvision Camera Optical Unit as follows:

1. Geometrically, the three images are formed similarly through a highly corrected system which results in resolution and overall contrast characteristics comparable to those produced by high-quality objectives considered standard by the motion-picture industry. Contrast measurements were made with the Cooke Speed-Panchro, $f/2$, 35mm lens as reference, in the following manner: A white screen with a square aperture in the center was prepared, behind which — at a considerable distance — was located a black velvet backing. This subject was obliquely illuminated to avoid direct illumination falling upon the black velvet. This maximum-contrast test subject was photographed and the sensitometric data indicated no significant difference.
2. Spectral characteristics of the new system as calculated closely match the Wratten tricolor filter set.
3. With the Colorvision Unit, Eastman Plus X Panchromatic Negative film, normally processed, requires a minimum set-lighting level of 150 ft-c. This is based on a maximum aperture calibrated as being T-2. The actual geometric aperture of the Colorvision Optical System is considerably greater than $f/2$. However, several interesting considerations have brought about the T-2 rating. Due to the new system's giving an image smaller than academy aperture, greater depth of field would normally be found for any given geometrical stop. As a means of bringing the depth of field of this system closer to that normally found for a given stop, and at the same time allowing black-and-white film to be exposed at approximately normal exposure index ratings, a compensated transmission calibration method has been used. As an incidental effect, this calibration approach approximately compensates for the energy reduction in each of the three images caused by the spectral division of the light necessary to obtain color separation. As a result, the maximum aperture, although considerably greater than $f/2$, is calibrated as T-2 with smaller stops based on the usual increments as determined by transmission measurements.
4. The angle of view of the entire system is directly related to the characteristics of the bayonet-mounted objective lens. Various objective lenses have been designed with characteristics giving angles of view from 28-mm to 125-mm

Presented on October 19, 1954, at the Society's Convention at Los Angeles by Lawrence F. Brunswick, Colorvision, Inc., 109 N. Larchmont Blvd., Los Angeles 4.
(This paper was received October 7, 1954.)

The Colorvision Corp. would be glad obtained from existing color negatives or

Fig. 1. Black-and-white negative, showing three color separations taken with the Colorvision Camera Unit: lower left, red; upper left, green; upper right, blue. Note variation in pattern of stripes in dress in each image. Lower right blank may be used for recording data. Total frame size is standard full aperture of 0.970 by 0.730 in. Each image is 0.480 by 0.360 with spacing of 0.010 in.

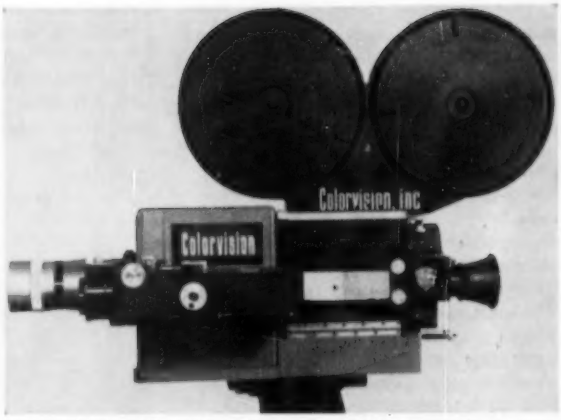

Fig. 2. Colorvision Camera Unit with 75-mm lens and NC Mitchell camera attached.

equivalents for normal 35mm photography. Focal length equivalents beyond the 28-mm and 125-mm range have not yet been undertaken, but are quite practical should the need arise.

5. Since all three images are formed through a single entrance pupil simultaneously, there is no parallax of any kind whatsoever.

6. The same controls that are normally found on a professional motion-picture camera are found on the Colorvision Camera Unit in the same equivalent positions, and are operated quite typically.

7. The weight of the Colorvision Camera Optical Unit is approximately 16 lb. Due to the fact that the Mitchell Camera base (which weighs 10 lb) is replaced, this represents an increase in weight of the camera equipment of approximately 6 lb. A modified Raby Blimp is used when shooting with sound. Three major Colorvision accessories to existing equipment have been developed: (1) the Camera Optical Unit; (2) the Optical Printer Superimposition Unit; and (3) the Additive Projection Lens for television reproduction or preview.

From the practical standpoint, because of the excellence of the motion-picture cameras in wide use, it was decided that there was no necessity to design a complete integral camera; in fact, tangible advantages would be realized by fabricating the Colorvision Camera Optical Unit as an accessory to existing cameras.

Therefore, the Camera Unit (see Fig. 2) was designed to operate in conjunction with the NC Mitchell, and is basically a beam splitter of unique design, mounted in a housing which provides a substitute for the "L" shaped base and "rack-over" on which the NC Mitchell is normally supported. However, adaptation to other 35mm cameras may be readily accomplished. The beam splitter is designed to place three separation images in the full aperture of the camera, each having a dimension of approximately 360 × 480 thousandths of an inch; thus each image is 40% greater in area than a 16mm frame. It was thought that such a size represents an excellent compromise for television application. These three images contain complete color information as required for either direct or additive color television transmission, or as an alternate for typical subtractive color prints, either 35mm or 16mm.

For color kinescopes the new Camera Unit, attached to a rapid pulldown camera and using panchromatic negative film, has an important application. In this instance, the high-speed processing would allow color kinescopes to be processed within the stringent time limitations existing. Technically speaking, it may well be desirable for color kinescopes to be recorded, not from the assembled color image, but by maintaining the separate color information carried on the three black-and-white kinescope tubes. This information could then be conveyed, without assembly, through an optical system and photographed in the form of three images on one 35mm frame, similar to that found in the Colorvision system.

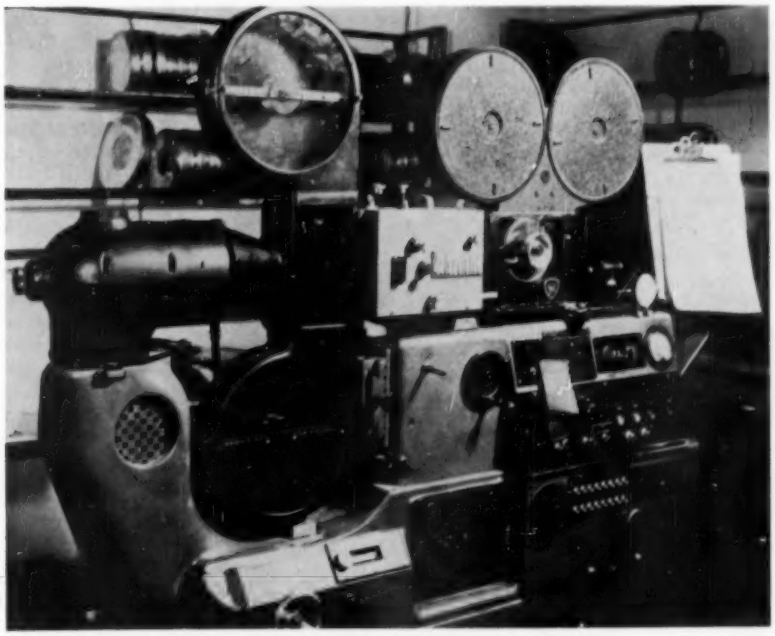

Fig. 3. Colorvision 35mm Optical Printer Superimposition Unit in operating position on Acme Dunn Optical Printer. Light source and negative film are on left side, positive film on right side. By reversing the Unit on the Optical Printer, color negative or positive may be broken down to 3-color black-and-white separations.

The Colorvision Corp. would be glad to cooperate with any engineers of the television industry who are interested in this application.

For black-and-white television transmission, either the information found in the green separation may be used, or for a typically panchromatic reproduction, the three superimposed separation images may be utilized.

The relative aperture of the system with all focal lengths of lenses is rated *T*-2. The efficiency of the Camera Optical Unit is such that Plus X film may be properly used under incandescent light with an exposure index rating of approximately 32, on the ASA scale with normal processing. This results in a minimum set-illumination level of approximately 150 ft-c with Plus X, a light level much more typical of black-and-white photography than of color.

The Colorvision Optical Printer Superimposition Unit (see Fig. 3) is an accessory to be used on an optical printer in place of the optical-printer lens, and serves the purpose of assembling the three black-and-white separation images into a full-color single image. By this means, the usual type of subtractive color print may be made from the Colorvision black-and-white negative, and may be projected normally.

The various controls on the Superimposition Unit (see Fig. 4) relate to image placement to obtain perfect superimposition. These normally function in a fixed position but allow for compensation in the event of excessive film shrinkage. Filter slots in each of the three channels provide for ready insertion of filter packs to match any color material that may be used. In addition, color-compensating filters placed in their normal position near the optical-printer lamp houses are used for timing.

The unit can be operated in reverse, thus providing a method for breaking down color film into black-and-white separations. By this means, low-cost color separations on black-and-white film, similar to direct separations, may be obtained from existing color negatives or positives for color-television transmission. Thereafter release prints for color television may be made on black-and-white stock by contact from the separations thus obtained. A Colorvision Superimposition Unit for reduction to 16mm is planned.

It is important to stress that for full color-television transmission, only the original black-and-white separation negative or a contact print from it is necessary. In this manner, full advantage is taken of the low-cost and high-quality reproduction inherent in the additive process. Obviously, either the original negative image or a contact positive therefrom is equally suitable for color-television use, since it is standard practice to operate from either a negative or a positive image. In any case, only black-and-white materials are required.

Fig. 4. Colorvision 35mm Optical Printer Superimposition Unit. Controls are provided for each color separation.

Colorvision Additive Projection forms an image in full color from the black-and-white separations. This image in turn may be broken down into its primaries for transmission in precisely the same manner as a subtractive color print. It would appear, at first consideration, that such a method would negate the inherent quality advantages of direct separation images. However, such is not the case, because by proper selection of the filters used in the Additive Projection Lens, color desaturation can be avoided. In this application, it is quite practical to choose filters of narrow band characteristics sharper in spectral cutoff than the dyes found in color prints. For example, replacement of the normal lens with a suitable Colorvision Additive Projection Lens in the associated projector of a three-vidicon color-film camera system would place the color information into the color-television transmission chain as outlined above.

A method technically more direct, and possibly to be preferred due to its simplicity, would project each of the three separation images onto the corresponding vidicon, or its equivalent, by means of a normal projection lens and a simple mirror system, without introducing any color, per se.

Further application of additive projection may be made for review purposes. While the inherently low efficiency in a practical additive projection lens precludes the application of this method for large-screen projection, adequate illumination for small-screen projection may be readily obtained for viewing daily rushes.

Technically and economically, the Colorvision process represents a forward step toward the solution of several important problems relating to color television. By means of this new process it is possible for the film producer, faced with the knowledge that his present black-and-white films are becoming obsolete, to photograph in color; and from a cost and operational standpoint, still retain many of the aspects of black-and-white photography.

In conclusion, the immediate use of Colorvision lies in its application to the kinescoping of color shows, and of providing an economical means for today's productions to be photographed additively for immediate showing in the black-and-white medium, with future residuals when issued in full color.

Combat Television

By EDWARD L. SCHEIBER
and HUGH C. OPPENHEIMER

The first public demonstration of combat television was presented at Fort George G. Meade, August 11, 1954. The Signal Corps Interim Tactical Television System was integrated as an operating part of the communications system of a Regimental Combat Team in a simulated combat maneuver. Further system integration was required when this demonstration was presented in color by NBC over their national network.

THE CONCEPT of using television as a means of battlefield communications has long provided a fertile field for the imagination and has presented us with many intriguing possibilities. With the rapid development of television some of these flights into fantasy have approached the realm of reality.

Although early in the history of television, experimentation and tests were made of possible military applications, it has been only recently that positive results have been possible. However, after a preliminary study of the capabilities of television, the Signal Corps felt that before any expensive and time-consuming research and development should be undertaken, a certain amount of exploratory work must be done so as to define the most promising areas of military application. Therefore, the Army Pictorial Service Division of the Office of the Chief Signal Officer, Washington, D.C., directed the Signal Corps Pictorial Center, Long Island City, N.Y., to design a television system made up of military and commercial equipment presently available and incorporating the maximum tactical capabilities.

Basically, the requirements were for a small portable system capable of relaying a satisfactory picture from the front lines to the battlefield commander and his staff, where it could be displayed, coordinated with other sources of intelligence and evaluated.

It was evident that the guiding principle of the system design and standards for this exploratory unit would have to be maximum picture quality compatible with equipment requirements for minimum size, weight and power consumption. Military considerations would have to be weighed against technical limitations. The initial factor to be determined was the desired resolution capability of the system. Most of the important information which the system would be required to reproduce with intelligible fidelity would be of a "long shot" nature such as a group of soldiers moving down a hill some 300 yards or so from the camera.

Broadcast experience in televising outdoor events from a distance indicated that anything less than a 525-line system might be insufficient. It was felt that some practical experiments to determine whether a 525-line system would be sufficient were in order, since televising groups of soldiers in a tactical situation is not as familiar a problem as televising football players in brightly colored uniforms from atop a football stadium. Therefore, experiments were conducted, using standard television-broadcast type equipment to televise various activities that might be encountered under combat conditions. Evaluation of results indicated that, generally, a 525-line system would be sufficient.

It had been decided previously that a signal-to-noise ratio consistent with broadcast standards would be required throughout the system, and that a 20-to-1 contrast ratio should be sufficient. However in an attempt to eliminate large complicated synchronizing generators, not all the RETMA signal specifications were adopted.

The use of the vidicon cameras was clearly indicated. Besides being small and highly portable, they are capable of sufficient resolution, possess an excellent signal-to-noise ratio and are quite simple in setup and operation. The vidicon has a suitable life expectancy and in general does not require the care that an image orthicon does, especially with regard to beam alignment and "picture sticking."

Our basic concept of the system had included the use of the man-pack transmitter. However, these are still in the developmental state and it was felt that in the interest of speed and economy a substitute could be used in this interim system. With the vidicon equipment commercially available, experiments demonstrated that camera cables up to 500 ft could be used without objectionable degradation of picture quality and cables of this length could be pulled along without too much effort by the cameraman. Therefore, it was determined that the first relay could be accomplished by cable in this interim system. Further, vidicon camera control equipment is, in general, small and light enough to be mounted in a small vehicle, such as the jeep or ¾-ton truck. All of this would fit nicely into the plan of mounting the control equipment.

As the radio relay link used to transmit the vidicon signal back to the rear control area also had to mount in the vehicle, its power consumption, size and weight were considerations. However, even more important was determination of frequency. Many factors influenced this decision. These were both technical and military. Technically, the system required a frequency with favorable propagation properties for distances up to 10 miles and required a channel or channels 8-mc wide, because no provisions for sideband suppression were being made. From a military standpoint, several other considerations were also very important. First, interference to or from other friendly communications could not be tolerated. Secondly, a frequency minimizing the possibility of signal interception and of signal jamming by the enemy and a frequency minimizing the possibility of supplying range-finding information to the enemy was desirable. These factors all pointed to the use of channels above 300 mc. The only bands available were between 300 and 400 mc and between 5000 and 8000 mc. Both deserved consideration, since both presented definite advantages and definite disadvantages.

In the 300- to 400-mc band, interference to and from other units in the area may become more of a problem than in the high-frequency range, and there is a greater opportunity for enemy interception. In order to avoid signal interference at the receiver station when using this band, a separate and distinct 8-mc channel would have to be assigned to each forward unit. The availability of a sufficient number of 8-mc channels in the lower-frequency band is very much a problem. However, this band does have a definite advantage in that the wave propagation properties are not strictly line-of-sight, and there is not the requirement for critical transmitter to receive antenna orientation. This latter allows for a greater mobility of the forward units.

In the 5000- to 8000-mc band there is less chance of enemy interception and jamming and less susceptibility to any outside interference. Further, the requirement for 8-mc channels would not be hard to meet. However, the line-of-sight transmission of the microwave beam required at these frequencies is both an advantage and a disadvantage. It is advantageous in that a single frequency channel can be used for reception of many forward-unit signals. No interference will be experienced since each unit will be operating from a different direction. Its disadvantage is that it is strictly a line-of-sight transmission and requires a critical transmitter to receive antenna orientation. The need for this critical orientation would restrict the mobility of the forward units.

In the equipment commercially avail-

Presented on October 19, 1954, at the Society's Convention at Los Angeles by Lt. Col. Edward L. Scheiber and Capt. Hugh C. Oppenheimer (who read the paper), U.S. Army Signal Corps, TV Branch, APSD, OCSigO, Pentagon, Washington, D.C. *Photographs courtesy U. S. Army.*
(This paper was received on December 3, 1954.)

Fig. 1. Cover and concealment are as important to the tactical television cameraman as they are to the infantryman. The picture being televised by this cameraman on the front lines is being viewed simultaneously by battalion commanders at the Command Post, located several hundred yards behind the front lines.

Fig. 2. This parabolic reflector is the microwave transmitting antenna used by this Tactical Relay Unit to send pictures from front lines to rear eschelon areas.

able there is little difference in the power-consumption requirements of either transmitter. However, the microwave's large parabolic antenna system does cause some concern. It is not only difficult to store and carry, but also it presents a tactical problem of concealment. From an engineering viewpoint a better antenna location than atop a high hill could not be found, but tactically it could not be worse. However, in considering the intended purpose of this interim system, namely to explore areas of application, the difficulty in obtaining the extra channels required for the 300- to 400-mc band and the fact that portable lightweight commercial equipment in the higher region was available dictated that we proceed with the less desirable microwave system.

The forward-unit equipment was to be commercial type, and would be capable of operating from a 110-v 60-cycle a-c line, hence the power-supply problem was not difficult. A gasoline-powered generating system in a trailer should suffice. Since the sum total of the equipment in the unit required less than 1 kw to operate, the generator could be quite small. However, some apprehension concerning frequency regulation was well founded. The camera count-down circuits in the synchronizing generator referred their 60-cycle pulse to the power-line frequency in order to help stabilize the counters, but, since the power-line frequency in this case was a function of generator load, engine speed, output voltage and almost every other variable throughout the system, the power frequency was quite unstable and not dependable, and the count-down circuits generally were more stable than the reference-generator frequency. Of course, the reference-frequency fluctuation caused similar synchronizing-generator fluctuation. This made little if any difference within each individual unit, but caused major concern to the operator at the command station, who often found the synchronizing signal from the units differing so greatly that the command monitors would lose synchronization. The simplest solution to this problem was to have the count-down circuits stabilized by referring them to an accurate crystal oscillator in the synchronizing generator. This solved the problem, although an occasional "roll over" during switching could not be eliminated, since there could be no guarantee that the reference-oscillator frequencies were in phase.

It should be pointed out that no mention has been made thus far of intercommunications between the units. Suffice to say that this problem was solved by the use of standard military communications equipment, which have proven satisfactory.

We are now at a point to see the complete forward unit consisting of a vidicon camera chain with a simple synchronizing generator producing a 525-line interlaced picture (Figs. 1 and 2) which in turn feeds a microwave transmitter sending the information to the command receiver unit. Figure 3 shows the complete forward unit less the camera. The power for this forward unit is supplied by a standard military-type gasoline generator.

The largest part of the tactical system is the command post unit (Fig. 4). In this

Fig. 3. Complete forward unit, except for camera.

Fig. 4. The command post unit.

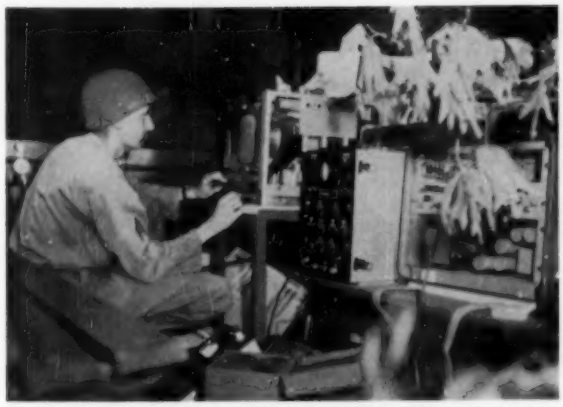

Fig. 5. A local control-room monitor.

Fig. 6. The airborne television unit.

unit all the pictures from the front-line units are received and coordinated. A 2½-ton Army shop truck was selected as the maximum-size truck that could be used to house the system and this was none too large since considerable equipment had to go into this unit. Not only was it necessary to build the central control room in this truck, but all the remote command monitors, spare parts, tools, extra cable and test equipment necessary to keep it and all the forward units in repair had to be included. Portable-type microwave receivers were used rather than rack-type equipment since field conditions might call for a setup in a place other than the truck.

The output of these receivers was fed through local control-room monitors into a six-input three-output switcher (Fig. 5). In this manner the control operator could feed two outgoing lines and one local monitor line. This keeps the system flexible enough to meet all command requirements in the field. Selection of the main power-supply generator for this unit presented no particular problem. The unit did require somewhat more power than the front-line units, but there was not too serious a limitation with respect to size.

Integrated into the unit was an airborne television system (Fig. 6). This consisted of a modified image-orthicon type camera and Block III transmitter mounted in an L-20 Canadian Beaver. This system was built at the Signal Corps Engineers Laboratories, Fort Monmouth, N.J., and has a range of 30 mi under optimum conditions. The airborne signal feeds to the base unit where it is integrated with the other pictures. Figure 7 shows the complete Interim Tactical Television System.

After the assembly and shakedown tests it was essential that the unit be used in a full-scale maneuver where immediate experience could be obtained under simulated combat situations. Therefore, it was sent to Fort Bragg, N. C., where Exercise Flashburn, the "new look" maneuver, was scheduled to take place in April and May, 1954. There the unit was integrated as an operational part of the maneuver and attached to a Regimental Combat Team. This represented the first time in history that a U.S. Army combat unit had for its command support a tactical television system.

The tactical situation that the Regimental Combat Team was engaged in was a series of defensive positions with two night withdrawals and one daylight withdrawal. A television monitor with its photointerpreters soon became as much a part of the S-2, S-3 sections as the telephone. Equipment functioned well with no failures. Some of the missions television was used for included: verification of information and intelligence received from other sources; location of enemy activity; study of road networks; control of friendly troops; transmission of pictures of captured enemy materiel; study of friendly camouflage and protection; location and evaluation of target areas; and use as a briefing aid.

After Exercise Flashburn the Tactical Television Unit underwent a series of changes and modifications. Most of these were of a minor nature directed primarily to simplify operations. However, it was found that the simple synchronizing generators in the forward units were not satisfactory. They had been used in an attempt to avoid the more complicated and bulky RETMA synchronizing generators. However, they did not transmit a composite synchronizing signal and at times the command monitors found it difficult to lock on the drive signals alone. In addition, occasionally the cameras would fail to interlace causing a serious decline in picture resolution. Therefore, RETMA synchronizing generators had to be added to the system.

In July, the unit reported to Fort Meade, Md., to prepare for the first public demonstration of tactical television which took place on 11 August 1954. Cooperating in this venture were the 2d Army, the 3rd Cavalry Regiment, the Radio Corp. of America and the National Broadcasting Co. This demonstration was divided into two phases. The first phase, for members of the Department of the Army Staff, presented in detail a simulated combat situation wherein a combat commander used television as a reconnaissance, surveillance and con-

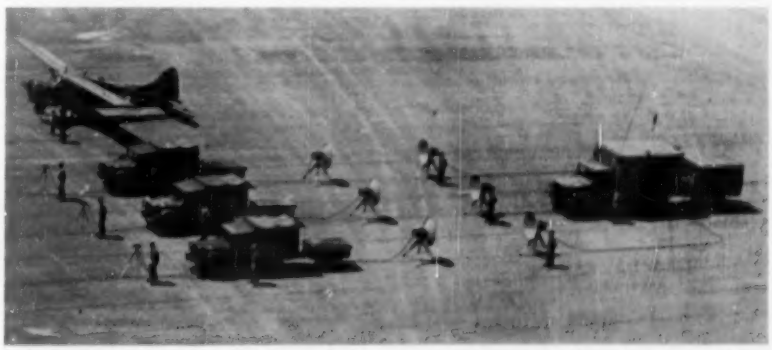

Fig. 7. Chain of command setup showing how broadcast would be relayed from front line camera man to ¾-ton truck containing PE-75 generator and sent on microwave to M-109 shop truck (2½-ton) which would also receive broadcast from (L-20 beaver) camera plane.

Fig. 8. Facilities for control of the cameras.

Fig. 9. This parabolic reflector is the microwave transmitting antenna used by this tactical relay unit to send pictures from front lines to rear echelon areas.

trol measure in various aspects of his tactical operation. The second phase repeated certain high points of the use of television in the tactical maneuver and was covered on a nationwide television color broadcast by the NBC Color Mobile Unit.

A command post, set up in a large tent to accommodate official visitors and the press, was arranged to represent the field headquarters of an Armored Cavalry Regiment equipped with full combat television facilities. Control of the cameras was effected for the Commander through his Television Control Officer. (Fig. 8.).

The airborne camera was to be used to show the progress of attack, the moving front lines and to spot enemy activity. The ground cameras were to be used to accompany a tank-infantry attack across open terrain, participate in a river crossing with the television camera operating from amphibious armored personnel carriers and follow through on the skirmish and assault on a fortified position at the beachhead.

The water crossing presented a new problem. The front-line units would be placed in landing craft with assault troops. Microwave orientation would be difficult. No knowledge of previous experimentation or experience of this type was available. Rough water during the crossing could cause all picture information to be lost. However, the tactical situation dictated that it be done, so we experimented with removing the parabolic reflector on the microwave transmitter. This, of course, had several effects, the most important of these being a decrease in directivity which meant that the signal at the receiving site, located on the shore, would remain relatively constant despite limited motion of the amphibious vehicle. The receiving unit retained its dish and an attendant optically tracked the transmitter (Fig. 9). Operating the microwave equipment in this manner was a field expedient, but accomplished its purpose.

The recently developed Signal Corps 100-in. lens was used by attaching one of our field cameras to it on the near shore (Fig. 10). Results were satisfactory.

Two of the front-line units were driven aboard the assault craft and one unit remained at the point of departure to televise the progress of the assault craft. The two units accompanied the assault troops in the attack. When the beach had been secured, the units followed through on the attack. The signals were consistent and no trouble was experienced.

The visual intelligence supplied by television enabled the combat commander to maneuver instantly as the tactical situation developed and, as was commented on in Exercise Flashburn, the immediacy of television gave the battlefield commander an initial psychological advantage never before possible.

From an engineering viewpoint this exercise was much more successful than the Flashburn operation. This, of course was to be expected, but new problems were found even here, and these, we hope, will be corrected in the future by the introduction of further modifications.

The demonstration, called "Operation Threshold," was just that: the threshold of a new concept in battlefield communications. This and Exercise Flashburn have very definitely established the feasibility of using television in tactical operations. Television is not a cure-all for military communications problems, but it is an important supplement to our regularly accepted means of pictorial communications and can effectively increase the amount of information available to a commander in the field. It will be thoroughly tested before being adopted for general military employment, but the work done by the Signal Corps Interim Tactical Television System has shown that television can provide a new and important tool in the conduct of modern warfare.

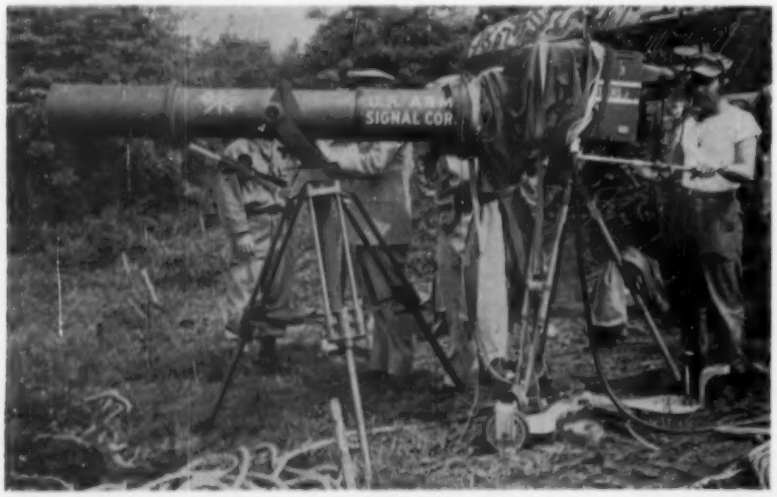

Fig. 10. The new 100-in. lens is mounted on television camera to be used in the telecast, TV in Combat, at Fort George G. Meade, Md.

Equipment for Evaluating Lenses of Television Systems

By EDGAR HUTTO, Jr.

A lens bench has been developed incorporating a nodal slide and a flat-field indicator which permits the rapid determination of the square-wave flux response of a lens both on and off axis. A synchronously driven test object is used, and a plot of response vs. line number is presented on an oscilloscope. Lenses up to 24 in. in focal length and $3\frac{7}{8}$ in. in diameter may be tested.

In the past seven or eight years new methods for evaluating the performance of optical systems have been developed. Electrical testing methods have been used to supplement the strictly visual means of determining the point at which a lens fails to perform satisfactorily. With the new techniques the degradation characteristic of the lens from low line numbers to high line numbers can be determined, whereas in the visual tests only the line number at which a lens fails to resolve can be found.

Herriott has described a photoelectric lens bench in which an oscilloscope trace is presented which shows the spatial distribution of energy in the image formed by the lens under test.[1] Schade has developed and described methods of evaluating all components of an image-producing system, such as a television chain or a motion-picture process.[2] Equipment for testing large Schmidt-type projection optical systems has been built by Parker, Johnson and Sachtleben.[3] Each of these equipments was built for research projects. The equipment which will be described in this paper does not represent a commercial design, but it does incorporate features which permit the rapid determination of lens response at a number of apertures and field angles.

Three main components are needed to test photographic-type lenses: a test object, a lens bench, and a photoelectric pickup device and its associated electrical equipment.

The simplest type of test object is the alternate black-and-white line pattern or square-wave flux pattern. Sine-wave test patterns are preferable for specifying image quality, but the relative ease of making the square-wave pattern dictated its use. Square-wave response data can be converted into sine-wave response data.[4] To obtain the scanning action necessary for electrical testing there must be relative motion between the test object and the phototube slit. Movement of the test object is the more convenient. The lowest magnification at which the majority of lenses will be tested is about 25 times. Hence, the test object must have line widths fine enough to test the lens to the desired line number. Two hundred (200) television lines/mm has been chosen as the highest line number that will be needed when the lens is 26.4 focal lengths away from the test object or at a magnification of 25.4 times. The finest lines on the test object are then 0.005-in. wide or 200 lines/in. If it is desired to test a lens to a higher line number a greater magnification must be used. The test object should be constructed so that the lines of the object may be horizontal or vertical providing a test for both tangential and sagittal image surfaces of the lens.

The lens bench should accommodate lenses up to 24 in. in focal length and 6 in. in diameter without time-consuming setups. A nodal slide and a flat-field device are necessary so that the lens may be tested off axis. A microscope should be used to enlarge the lens image so that the phototube slit need not be extremely narrow.

The phototube and its amplifier should be capable of presenting a noise-free signal when the lens is stopped to $f/16$. The amplifier must pass a square wave corresponding to the finest lines of the test object.

The Test Object

The test object or scanning drum is revolved by an 1800-rpm synchronous motor. This provides the relative motion between the lens image and the phototube slit. The scanning drum was fabricated from Plexiglass. It has a $\frac{1}{8}$-in. wall and is 3 in. long with an outside diameter of $5\frac{1}{2}$ in. The circumference of the drum is divided into eleven approximately equal sections. Two of these sections are used to provide signals for reference levels on the oscilloscope presentation. The remaining nine sections consist of alternate black and white lines. The line width in any one section is constant. The number of television lines per inch of the sections are 3, 6, 10, 20, 40, 80, 120, 160 and 200. A milling machine with an indexing head to provide accurate spacing was used to cut every other line. These lines were filled with opaque lacquer to make the black lines, and the polished surfaces remaining formed the white lines of the test object. Although the lines extend the entire 3-in. height of the drum, only the middle 1-in. portion of the drum is viewed by the lens under test. The section giving the 100% response signal is 1-in. high also. This develops a voltage at the amplifier output which is the same as that which would be produced by a lined section through a perfect lens system. The section providing the zero response signal is $\frac{1}{8}$-in. high. This develops the same output that would be produced by a lined section through a lens system when there is a total loss of contrast.

The lines on the scanning drum are illuminated by a projection lamp through a suitable optical system. A blower is used to cool the lamp. The entire scanning unit may be rotated so that the test-object lines are either vertical or horizontal. Figure 1 shows the scanning assembly with the test-object lines vertical. The scanning drum was balanced statically and dynamically.

The Lens Bench

The lens bench has been built around two commercially available units. A

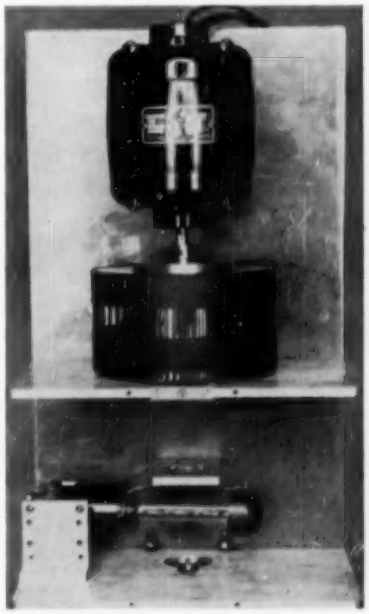

Fig. 1. Scanning assembly with cover removed, showing square-wave test object.

Presented on October 19, 1954, at the Society's Convention at Los Angeles by Edgar Hutto, Jr., Engineering Products Div., Radio Corporation of America, Bldg. 10-4, Camden 2, N.J.
(This paper was received on October 11, 1954.)

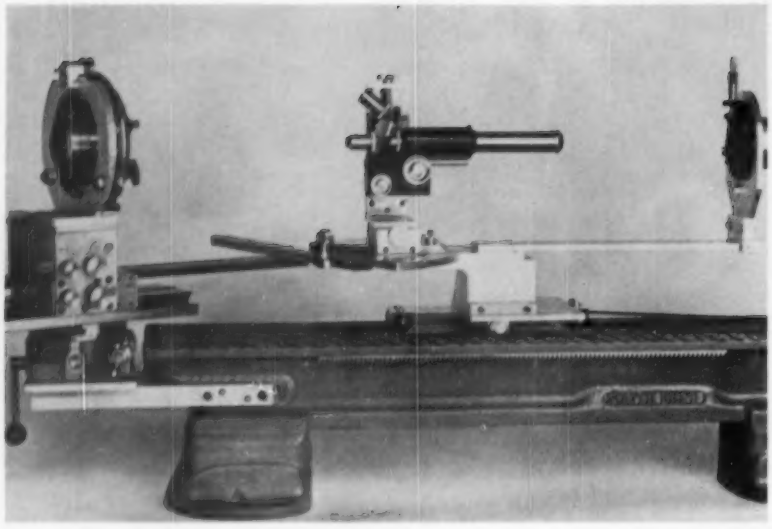

Fig. 2. An off-axis test at 27° on a 12-in. focal length lens.

4½-in. diameter indexing table is used as the support for the nodal slide, and a 36-in. long lathe bed from a 9-in. bench lathe is used for the microscope carriage ways.

The lens under test is mounted on top of the nodal slide. Two iris diaphragms are used to hold the lens. For short lightweight lenses only one diaphragm is needed. For larger lenses both diaphragms are used, and spacers are used to adjust the distance between diaphragms. Lenses having diameters from 0.875 in. to 3.875 in. can be held by the diaphragms. The lens holder is easily removable and a special holder or V-block will hold larger diameter lenses. The iris diaphragms are held on a ring whose outer edge is convex. This edge fits into concave grooves mounted on the outer races of three roller bearings. This permits the lens to be rotated and checked for centering.

The nodal-slide travel, and the lens mount are such that telephoto lenses, whose nodal point falls within 4 in. of the front lens, may be tested. A series of holes has been accurately spaced in the indexing table every 5° for a 45° interval on either side of the zero or on axis position of the nodal slide. A ground and hardened pin is inserted through a fixed reference hole into one of these holes for a repeatable and accurate rotation of the nodal slide and lens. This is necessary for lineup of the bench, and it is very useful when testing a lens off axis as the 5° intervals will generally be used. The lens can be rotated to intermediate angles as determined by the engraved scale on the indexing table although the setting will not be too precise. A locking device is built into the table to prevent rotation. A rack-and-pinion moves the nodal slide on its dovetail so that the transverse axis of the lens under test is on the axis of rotation of the indexing table. A coarse and fine movement of the slide is provided. Once the transverse axis of the lens is found the slide may be locked. The transverse axis of the lens is the axis of rotation for which there is no displacement of the image when the lens is rotated. For an object at infinity the transverse axis and second nodal point coincide.[5]

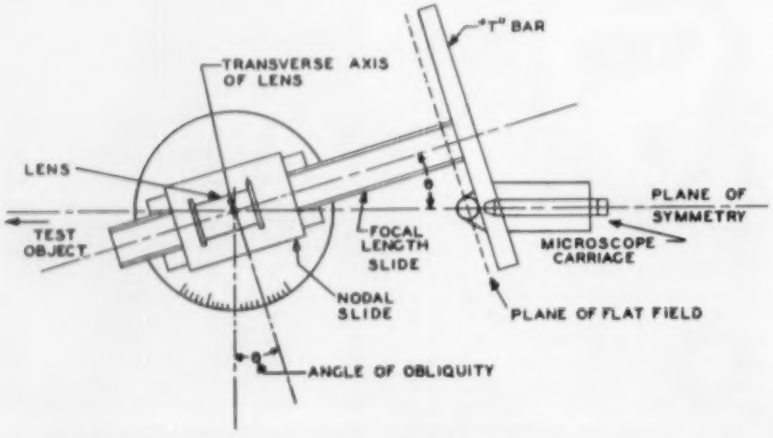

Fig. 3. Diagram of lens bench and the relation of main components.

The focal-length slide is mounted beneath the lens holder. A flat-field indicator or T-bar is mounted at the end of, and perpendicular to, the focal-length slide. The T-bar automatically defines the flat field of the lens under test so that the examining microscope is always focused on this plane when the nodal slide is rotated for off-axis test. A roller bearing on the front of the microscope carriage contacts the T-bar, thus moving the microscope carriage back along the lathe-bed ways as the lens is rotated. A counterweight attached to the carriage is used to maintain constant contact between the roller bearing and the T-bar. Three focal-length slide 9-, 20-, and 30-in. long are provided to cover the range of lenses which will be tested. The T-bar is 3-in. long on the shortest slide and 12 in. in length on the longer two. A rack-and-pinion is also used to move the focal-length slides. Coarse and fine adjustments are provided by gearing. Figure 2 shows a 12-in focal-length lens being tested 27° off axis. Figure 3 gives a view of the same test as seen from above, pointing out the principal items.

The microscope is mounted on small slides so that it may be moved vertically and perpendicularly to the lathe-bed ways. The microscope as purchased has fine and coarse focusing movements parallel to the ways. The microscope may also be rotated about the axis of the roller bearing which contacts the flat field bar. This is necessary when testing telephoto lenses. The microscope has a 215-mm tube length. Three compensating eye-pieces of 5X, 10X, and 25X are used with 32-mm, 16-mm, 8-mm and 4-mm objectives. These objectives were developed for use with metallurgical miscoscopes; therefore, they are corrected for use without cover glasses.

The phototube housing is mounted on a bar projecting from the rear of the microscope carriage. The housing may be moved along the bar and locked at any position.

The phototube slit is normally 10 in. from the microscope eyepiece, but if it is necessary to decrease the size of the image projected by the microscope, the phototube housing may be moved nearer. The phototube slit is adjustable in width by a micrometer head. The slit is 1½ in. long, therefore the enlarged lens image must never exceed this height or the 100% reference level on the response curve will be in error. The housing may be rotated so that the slit is either vertical or horizontal.

Phototube and Amplifier for Oscilloscope Presentation

A 5819 multiplier phototube is used as the pickup device. The output of the phototube is fed into a 6AG5 cathode follower mounted in the phototube housing. A cable connects to the amplifier and power-supply chassis. One section of a GL5670 twin triode amplifies the cathode-follower output, and the second section acts as a phase inverter. The oscilloscope may be plugged into the amplifier ahead of the 6AL5 rectifier. In this instance the peak-to-peak waveform is observed. This is useful when focusing a lens. The average rectified waveform is observed by using the jack after the 6AL5. When the scanning drum is revolved at 1800 rpm, the lines of the test object provide square-wave signals ranging from 52 kc in the fine detail down to 200 cycles/sec for the reference-level signals. The circuit shown in Fig. 4 has been found to be flat up to a 100-kc square wave. An overall view of the complete equipment is shown in Fig. 5.

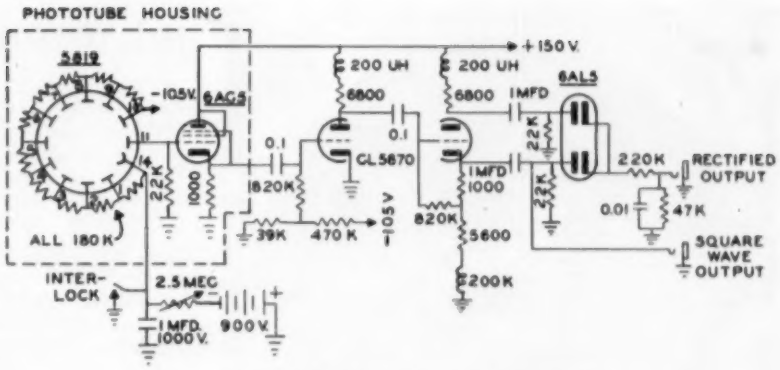

Fig. 4. Circuit diagram of photomultiplier amplifier.

Alignment of the Lens Bench

The methods of lens-bench adjustment as described by Houghton and Selwyn[6] and by Leistner, Marcus and Wheeler[7] were used where applicable to the present bench. As it is not planned to use the bench to measure lens aberrations some of the details of alignment were not followed.

The symmetry plane of the bench is defined as the plane containing the vertical axis of rotation of the nodal slide and is parallel to the ways on which the microscope carriage travels.

(a) The lens-mount center must be on the symmetry plane. A lens was placed in the lens mount and a distant on-axis object was imaged. The position of the image was marked. The nodal-slide turntable was rotated 180°, and the lens was refocused. The lens mount was moved laterally with respect to the symmetry plane until a position was found where there was no lateral displacement of the images when the lens mount was rotated.

(b) The crossbar of the flat-field indicator must be parallel to the lens-mount ring. The face of the block containing the focal slide was ground perpendicular to the dovetail. This face was used as the reference surface for setting the crossbar and lens mount. Parallel bars were clamped to this surface and mechanical measurements were made to the crossbar and to the lens ring. Adjustments were made until parallelism was obtained.

(c) The crossbar of the flat-field indicator must be perpendicular to the symmetry plane when the nodal-slide table is set at zero degrees. When this condition exists the roller bearing connecting the T-bar to the microscope carriage will not rotate as the focal-length slide is moved. A scratch was made on the bearing race, and a microscope with a reticle was focused on the scratch. The indexing table supporting the nodal slide was locked at its zero position, and the entire assembly was rotated on its platform until a position was found where there was no rotation of the bearing as the focal-length slide was moved in and out. The indexing table was then tightened on its platform.

(d) The microscope carriage roller center must be set on the symmetry plane. The nodal-slide indexing table was rotated to 45° clockwise from zero as determined by the indexing holes and was locked. The limit of the movement of the microscope carriage along the ways was measured with a dial indicator. The table was then rotated 45° counterclockwise from zero and the limit of the carriage again measured. When the roller axis is on the symmetry plane the carriage movement should be identical. The plate holding the microscope and the roller was moved laterally until the correct position was found. As a visual check a reticle may be placed in the lens holder, and the nodal slide is adjusted until the vertical line of the reticle is on the center of rotation. If the microscope is focused on the line at a certain rotation, it should also be in focus at the same counter rotation.

(e) The object plane of the microscope must include the axis of the microscope turntable and hence the roller-bearing axis. The microscope is focused on the reticle in the lens mount. By a combination of the microscope focusing adjustment and the focal-length slide adjustment, a position is found where there is no movement of the reticle image when the microscope is rotated on its turntable.

Procedure for Testing a Lens

The scanning drum or test object is placed 26.4 focal lengths from the center of rotation of the nodal slide. To be more exact, particularly for short focal-length lenses, this distance should be measured from the front principle point of the lens. The test object should be on the axis of the lens system when nodal-slide turntable is at zero degrees. A collimator may be used to align the test object with respect to the bench, but a simpler means has been used. The microscope is centered on a cross hair mounted in the lens holder by its vertical and lateral slides. The lens to be tested is then placed in the lens mount, and the test object is positioned with respect to the bench so that the lens image is centered in the microscope field. Except for telephoto lenses, the objective under test should be placed in the lens holder so that its physical center is approximately over the axis of rotation of the nodal slide. The microscope is focused on the image of the test

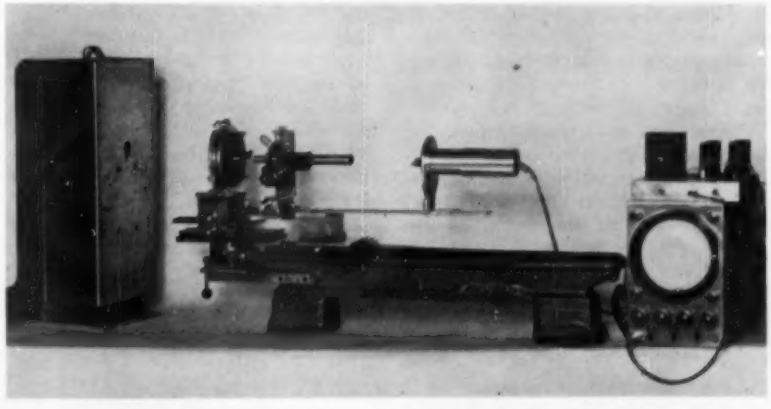

Fig. 5. Overall view of complete lens-evaluating equipment.

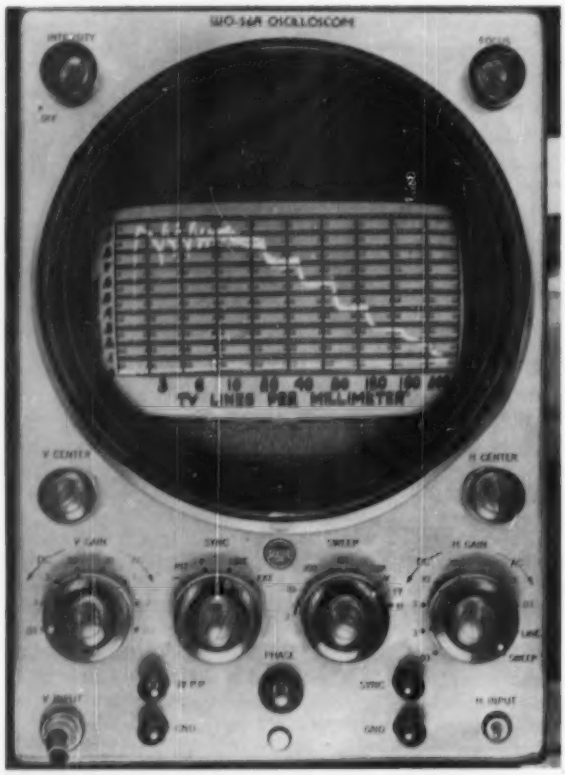

Fig. 6. Typical response curve of a 90-mm F/3.5 camera lens stopped to F/5.6.

object by adjusting the focal-length slide knobs. The lens mount is then rotated through several degrees about the zero position. The nodal-slide movement knobs are then adjusted until there is no lateral movement of the image during rotation of the lens. The nodal slide is then locked by tightening the locking screw on the slide gib.

For on-axis tests the indexing table is locked at the zero position. The microscope objective chosen to enlarge the image must accept the full cone of light from the lens under test. An 8-mm objective, with a speed of $f/1$, is most generally used. In this case its magnification is $21\times$; therefore, it is not necessary to use an eyepiece to enlarge further the image which falls on the phototube slit. The wavelength of the finest detail is then 0.0084 in.; the slit is set to one-third or less of this value.

The oscilloscope is plugged into the square-wave output jack and the waveform is observed. Fine adjustment of focusing is made while observing the scope trace and focusing for the maximum amplitude of the fine detail band. The focal-length slide is then locked. The phototube housing should be rotated so that the slit is parallel to the test-image lines. When the orientation is correct, the fine detail band is at a maximum. The photomultiplier gain and the intensity of the projection lamp must be adjusted so that the phototube does not overload on the 100% response signal. If the color temperature of the 750-w projection lamp is too low when its intensity is reduced, a 500- or 300-w lamp may be used in the test object.

To obtain the rectified waveform, the oscilloscope is plugged into the other output jack. A photograph of a typical trace is shown in Fig. 6. The relative amplitude of the various bands may be read directly from the grid or determined by the voltage-measuring means provided on the scope. Once the on-axis adjustments are made, all that is necessary to obtain off-axis measurements is to unlock the indexing table and rotate it to the desired obliquity.

For the complete study of a lens it may be desired to examine a star image. A point source is then used as the test object. The image is inspected with the microscope on the lens bench. The nodal slide is again used to rotate the lens for off-axis examination of the star image. The lens bench can also be used for the determination of the focal length of lenses. Once the rear nodal point of the lens is found, measurement of the distance between the axis of rotation of the nodal slide and the axis of the T-bar roller gives the focal length of the lens. In making this measurement, it must be certain that the object plane of the microscope falls on the axis of the T-bar roller. The test for this alignment should be repeated before focal-length measurements are made. The focal-length determination should be made with an object at an infinite distance or with collimated light if more convenient.

In the event that a sine-wave test object is easily procurable, the square-wave scanning drum can be replaced.

Conclusion

The lens bench provides a rapid means of determining the square-wave flux response of the majority of the lenses used in television systems. It has been found useful for the evaluation of new lenses, and it can also be used for the routine inspection of lenses used in production items. The sine-wave flux response of a lens which is derived from the square-wave flux response may be combined with the sine-wave response of other components of a television chain to obtain the overall system response. In the case of routine lens inspection, the response curve may be photographed from the oscilloscope for a permanent record.

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7. K. Leistner, B. Marcus and B. W. Wheeler, Jr., "Lens testing bench," *J. Opt. Soc. Am., 43:* 44, 1953.

Electronic Comparator for the Automatic Inspection of Magnetic Sound Prints

By JEROME W. STAFFORD

This paper describes an electronic system for comparing magnetic sound prints with the master track during the printing operation. In the release printing of CinemaScope pictures the comparator is a useful tool for the automatic inspection of the product. It has been in service at Metro-Goldwyn-Mayer Laboratory since December 1953 and has proved to be of great value in making CinemaScope prints.

THE USUAL procedure in making release motion-picture prints with optical soundtrack is to obtain, first of all, a satisfactory print, called an answer print. In preparing the answer print soundtrack densities can be adjusted throughout the picture to give optimum sound quality. Routine track inspection of subsequent prints then becomes a simple matter of measuring control densities at either or both ends of each reel plus a visual examination of the track by the operator who inspects the picture. With the introduction of magnetic-sound release printing, the necessity arose, therefore, for a new method of inspection. The actual running of the prints in a projection room would be not only too slow but too costly. The development of an electronic method seemed to be the solution, particularly with respect to ultimately increasing the speed of operation. The comparing of two audio signals, one from a master track and one from the copied track, in some sort of bridge circuit with proper error indication, seemed to offer maximum simplicity as well as reliability.

Figure 1 is the schematic of the system developed for use at M-G-M in the release printing of CinemaScope magnetic soundtracks. The block diagram section at the left gives the essential requirements of a transfer system for copying master magnetic tracks. The circuit section to the right shows the actual details of the comparing and error-indicating operation.

The master track is reproduced on a Westrex RA-1506 Recorder with the normal recording head used as the reproducing head, so that the output from the normal monitoring head can be used as a standard of comparison. The output of the reproducing amplifier is fed to a Y-pad, a recording attenuator, a recording amplifier, and finally to the recording head of another Westrex RA-1506 Recorder. The signal from the master monitor head and amplifier serves both as a standard in the comparing circuit and for direct audio monitoring. Finally, the signal from the copy monitor head and amplifier is compared to the standard signal in the comparing circuit and is also available for the audio monitor. The audio monitoring can be switched from direct to copy for the purpose of comparison.

The comparator circuit proper accepts the master standard signals and the copy signals through identical channels, each consisting of a constant-sensitivity input control, an input transformer, a diode rectifier and an RC integrating section. The algebraic difference of the integrated voltages of the two channels is impressed on one grid of a differential amplifier, the other grid of which is held constant. A sensitive relay, as well as a voltmeter in series with a resistance, is connected between the two plates of the differential amplifier. The meter indicates the amount and sense of the error voltage, while the relay is adjusted to operate a buzzer and signal light if the error exceeds a predetermined amount.

The biased rectifiers with series resistors R_1 and R_2 at the input of the comparator serve the dual purpose of compressing the signals above the 3% harmonic-distortion point of the magnetic film, and, due to their nonlinearity, of making the input amplitude response approximately a logarithmic function of the output voltage. Figure 2 shows this relationship, with level in dbm at the input plotted as abscissae against volts across the half-megohm resistor R_4 as ordinates. The four values of the resistor R_1 show how the response of the system can be compressed at the higher levels by varying the resistance. A value of 20 ohms seemed to be satisfactory for our operating conditions. Since the 3% harmonic-distortion point of the magnetic film falls at about +12 dbm, there is a level range of roughly 15 db below film overload with constant decibel amplitude response. As the level continues to decrease, the sensitivity decreases until at approximately 30 db below film overload it has vanished.

The transformers T_1 and T_2 give a voltage step-up of about five and a half to one in coupling to V_1, the 6H6 rectifier tube. The rectified outputs of the two halves of V_1 are integrated by C_1R_3 and C_2R_5. The algebraic difference of these two rectified integrated signals is impressed on the grid of one half of V_2, the differential amplifier. The other grid of V_2 is held constant, at a value determined by the IR drop in P_1. A voltmeter in series with a 50,000-ohm resistor, as well as a sensitive relay, is connected between the two plates of V_2. These serve to indicate magnitude and sense of the error.

The meter shows the amount and direction of the error continuously. However, it has not been calibrated in decibels. The relay is adjusted to operate at a value of approximately 2.5 v difference between the two grids of V_2. For signals in the upper 15-db range, this voltage difference corresponds to about 2 db.

The differential amplifier as used here operates at approximately unity gain. It simply serves, therefore, to change the error voltage from high impedance to an impedance sufficiently low to operate the meter and relay combination. It might be of interest to note that more gain, and therefore greater sensitivity, could be obtained with the use of a relay with a center tap coil arranged in push-pull output fashion.

The final step of the comparator is the operation of the signal light and buzzer in case an integrated discrepancy greater than approximately ± 2 db should occur. As shown at the right of Fig. 1, the error-indicating relay operates a signal lamp and a holding relay, which in turn energizes a buzzer. Once the error relay operates, the signal lamp, holding relay and buzzer continue to stay on until released by the push switch.

Since a complete comparison unit, Fig. 3, is required for each separate track, it is obvious that the design should be as simple as possible. In our design, therefore, two simplifying assumptions have been made. First, if in a transfer operation the voltage amplitude from the master audio signal integrated over approximately 0.04 sec is equal to the same integrated voltage amplitude from the copy, the two audio signals will be equal to within practical limits. Second, if in a transfer operation the audio signals from the original are equal to those from the copy over a 30-db level

Presented on October 20, 1954, at the Society's Convention at Los Angeles by Jerome W. Stafford, Sound Dept., M-G-M Studios, Culver City, Calif.
(This paper was received September 13, 1954.)

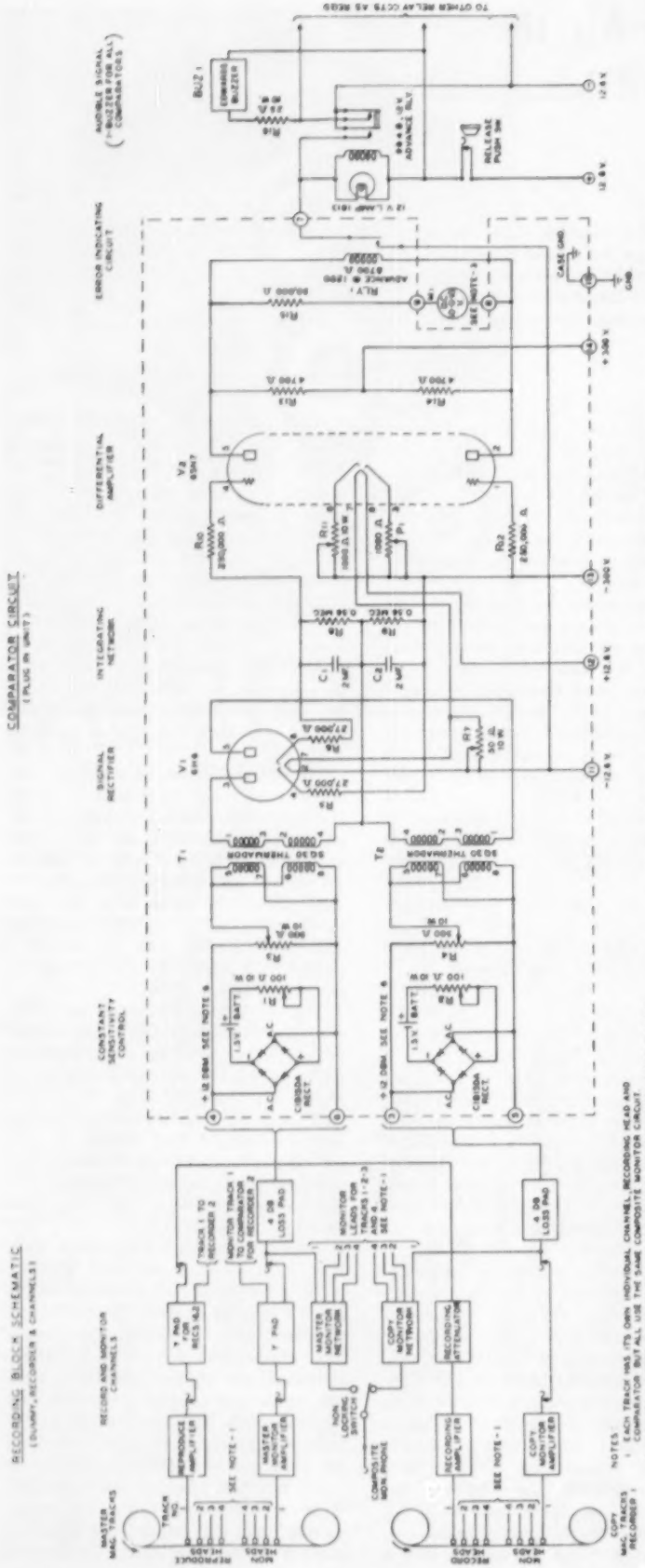


Fig. 1. Overall schematic of magnetic transfer system with details of the comparing system and error indicating circuit.

range from 100% modulation, the probability is that audio signals below −30 db will match satisfactorily.

If it were possible to maintain an exact phase relation between the original and copy audio signals, the first assumption would be unnecessary, and instantaneous amplitudes could be compared. However, there is always present a certain amount of phase shifting in the signals being compared due to the mechanical filtering; slight changes in film pitch, lack of perfect adjustment of recording and reproducing heads, and variations in the elastic properties of the film. Also present are slight amplitude discrepancies due to changes in film sensitivity, head sensitivity, film weave in passing over the heads, and position of the magnetic stripes on the film. As long as the summation of all these discrepancies is below a certain amount, the prints will be essentially perfect. We have found that by holding the overall average level of each track within 1 db ($\pm\frac{1}{2}$ db) and total momentary discrepancy within ± 2 db, the resulting prints will be entirely satisfactory.

Although it would be possible to design a comparator that would cover an amplitude range greater than 30 db, it seemed reasonable to assume that if audio signals match accurately from maximum level to approximately 15 db below, and if the sensitivity of comparison decreases with level from the −15 to vanishing at a level of the order of −30, the resulting prints would be completely satisfactory.

That the above simplifying assumptions were justified has been well proved by the actual use of the comparator. A prototype, Fig. 4, capable of comparing three soundtracks was made and tested during the printing of separate magnetic stereophonic sound for release. The system performed better than expected. It was therefore included in the layout of our CinemaScope printer, which required eight comparator units, four for each of the two prints being made. We have since set up a second similar printer so that in all we have nineteen comparator units in operation. They have all been completely satisfactory and have proved a useful tool for the automatic inspection of release magnetic soundtracks. Figure 5 shows the final M-G-M CinemaScope printer with its sixteen comparator units.

In the actual printing procedure, the operator can correct for changes in sensitivity of the various tracks by observing the comparator meters. This type of correction has proved advantageous as it can be used throughout the reel and insures more uniform soundtracks for theaters than could otherwise be obtained. The amount of this type of correction is approximately ± 2 db. Variations greater than this indicate unsatisfactory striping and the print is set aside to ascertain cause.

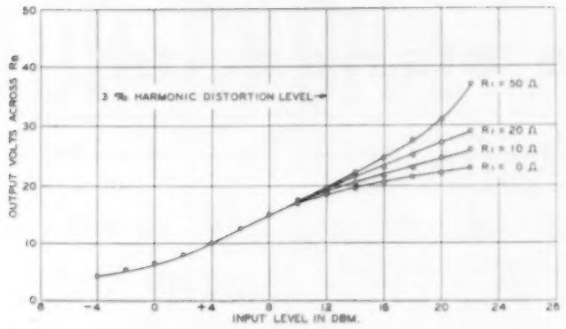


Fig. 2 Approximate logarithmic relationship between level input and rectified integrated output.

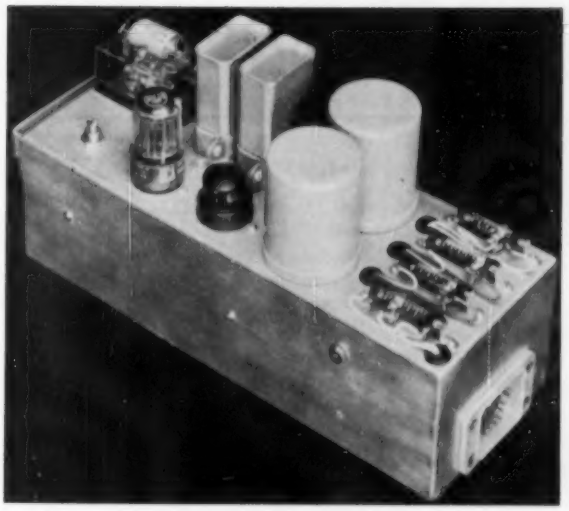


Fig. 3. Electronic comparator unit.

Fig. 4. Phototype with three comparator units.

M-G-M Laboratory has used the comparator in making CinemaScope release prints since December 1953. As of August 16, 1954, 15 million feet of film have been printed relying solely on the comparator as a means of inspection, with the gratifying result that no unsatisfactory sound has been sent out to the exchanges. Except during the initial testing stage, inspection by review-room listening has been entirely eliminated, thereby effecting considerable saving in both cost and handling time.

The writer wishes to express his appreciation to M-G-M's Director of Sound, Wesley C. Miller, for his enthusiasm in supporting the project, and to Kenneth Frierson for his help in the design and development of the system, as well as to the Westrex Corp. for furnishing photographs.

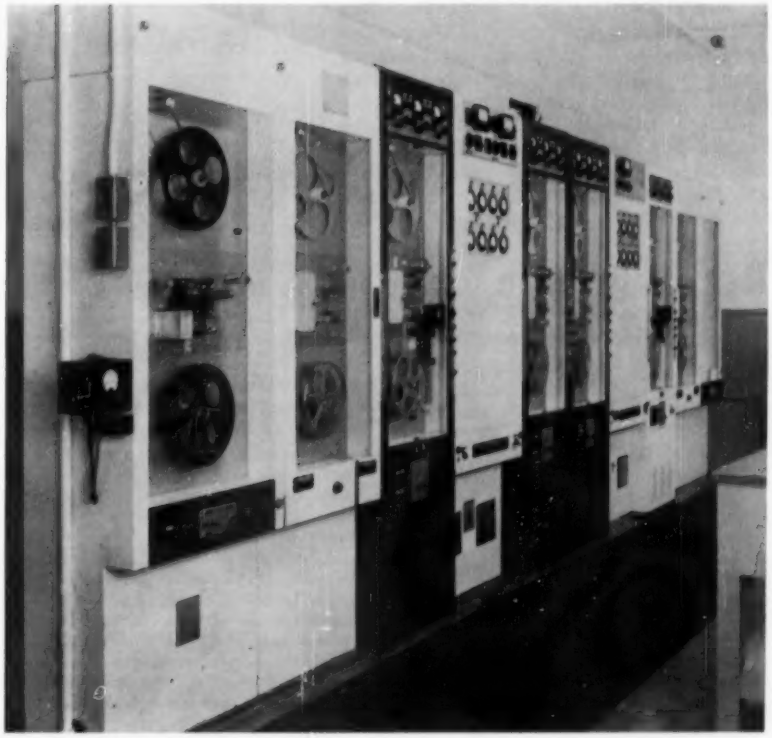


Fig. 5. Final M-G-M CinemaScope printer with its sixteen comparator units.

motion-picture standards

Proposed American Standard PH22.88

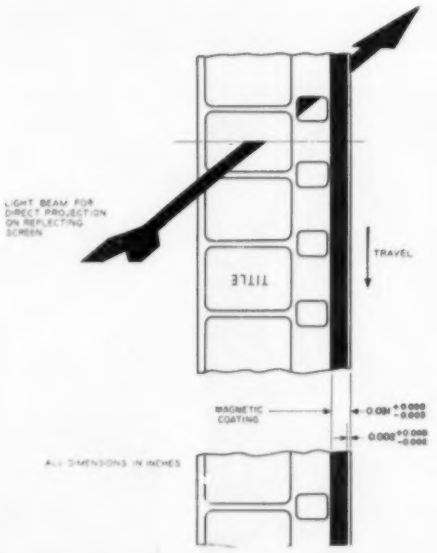
A Proposed American Standard, PH22.88, Magnetic Coating of 8mm Motion-Picture Film (fourth draft), is published here for a six month period of trial and criticism. Comments should be sent to Henry Kogel, Staff Engineer, prior to August 15, 1955. If no adverse comments are received, by that time, the standard will then be submitted to the ASA Sectional Committee, PH22, for further processing as an American Standard.

The third draft of this proposed standard was previously published in the February 1954 Journal for a three month period of trial and comment. Exception was taken to the third draft on two counts: (1) at the time, only one projector employed the specified point of scan relationship whereas there were several kit manufacturers who located the point of scan before the picture aperture rather than after and (2) it was felt that because of reduction printing considerations, the projection rate of 8mm film should hinge on that established for 16mm film and this rate is not rigidly fixed at the moment. The proposal was therefore returned to the Magnetic Recording Subcommittee for reconsideration. The subcommittee redrafted the proposal as a purely magnetic coating specification with the intention of specifying the point of scan and rate of projection in a separate standard or SMPTE Recommended Practice when conditions permit. This draft was subsequently approved by the Sound and Standards Committees and is the one published now for trial and comment.—*H.K.*

Proposed American Standard

Magnetic Coating of 8mm Motion-Picture Film

PH22.88



The magnetic coating is on the side of the film toward the lamp on a projector arranged for direct projection on a reflection type screen.

NOT APPROVED

Letter to the Editor

Re: Flying-Spot Film Scanners

Regarding Mr. Traub's excellent paper,[1] the interplay between isotransport and optical compensation for film shrinkage should be further clarified for the benefit of the reader:

The kinematics of this kind of isotransport has to be compared with the problem of perforation frequency in sound film reproduction technique. The guiding of the film on the periphery of a uniformly rotating sprocket cannot secure an absolutely uniform film transport. With 35mm film, however, the continuous motion of the film is readjusted four times during each frame period by consecutive engagements and disengagements of sprocket teeth. It is entirely due to this occurrence of several very small discontinuities per frame cycle that for imaging purposes the film motion can be regarded as approximately uniform, having a speed characteristic to the degree of film shrinkage. And it is due to the validity of this approximation that optical compensation for film shrinkage is feasible with the described device.

Another remark may be permitted with regard to the light efficiency of flying-spot film scanning, which tends to become more or less critical in the case of color film of conventional subtractive type. This is due to the relative inefficiency of flying-spot emission, in combination with photoelectric response, in the green spectral range, which color component essentially determines the image resolution in additive color reproduction on the TV receiver screen. Although this circumstance does not cause prohibitive difficulties, looking for practical alternatives should be of special interest in view of the development of video tape-recording of color motion pictures. Against this background of the present situation it should be remembered that an excellent proposal for television transmission of motion pictures in color was published 23 years ago by Herbert E. Ives.[2] This early proposal remains fully modern with regard to the present requirements of color film broadcasting, although in the meantime television changed from mechanical to electronic scanning. Ives referred to the old American lenticular film "Kodacolor," which had the embossed cylindrical lenses oriented along the length of the film. It is a great advantage to scan across the lenticules, the latter facing the photo-electric tubes, because that way the three color image components will be picked up by geometrically separated beams, ending in the respective photoelectric tubes. Therefore, the film must be embossed longitudinally, not transversally. (This advantage of scanning across the lenticules would be lost with transversally lenticulated film.) Since no spectral separation is needed with Ives' proposal, the light efficiency would have the same order of magnitude as obtained with black-and-white film. Of course, the film scanner device described by Mr. Traub could be used for such purpose, provided that the three photoelectric tubes are suitably arranged.

It is strange that a seriously meant revival of the lenticular color technique in the United States came, a few years ago, with the choice of horizontal lenticulation, i.e. without taking care of possible television applications.

References

1. E. H. Traub, "A new 35mm television film scanner," *Jour. SMPTE, 62:* 45-54, Jan. 1954.
2. H. E. Ives, "Television in color from a motion picture film," *J. Opt. Soc. Am., 21:* p. 2, 1931.

September 14, 1954

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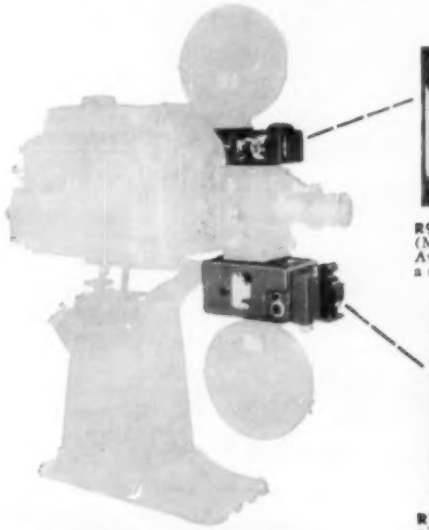

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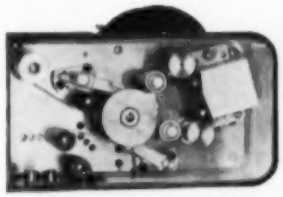

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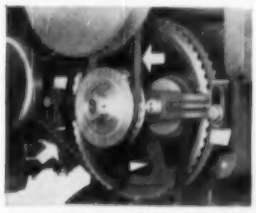

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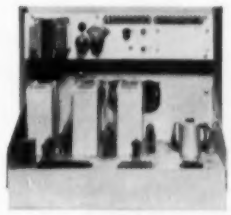

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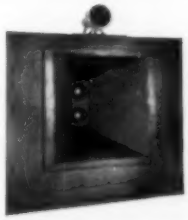

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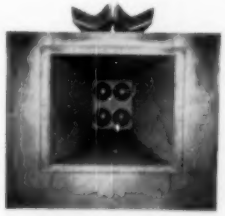

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77th Convention Local Arrangements at Chicago, April 18–22

The roster of chairmen who are making all the arrangements and who will pull all the strings, except for the deliveries of the technical speakers, has been announced by Byron Roudabush, Convention Vice-President:

Local Arrangements Chairman, James L. Wassell
Administrative Assistants, Robert G. Herbst, Harold W. Kinzle, Charles E. Lager, Robert L. McIntyre, John S. Powers and David W. Ridgway
Registration, Kenneth M. Mason
Hotel Arrangements, Lawrence S. P. Hanchek
Projection, I. F. Jacobsen
Public Address and Recording, Robert P. Burns
Motion-Picture Short Subjects, Kenneth M. Mason
Hospitality, Geo. W. Colburn
Exhibits, George L. Oakley
Transportation, George M. Ives
Publicity, Edward H. Seguin
Luncheon, Henry Ushijima
Banquet, Jerome C. Diebold
Membership, Harry W. Lange
Ladies Committee: Cohostesses — Mrs. Geo. W. Colburn and Mrs. Malcolm G. Townsley; Mrs. Jerome C. Diebold, Mrs. Lawrence S. P. Hanchek, Mrs. C. E. Heppberger, Mrs. George M. Ives, Mrs. Kenneth M. Mason, Mrs. Reid H. Ray, Mrs. Henry Ushijima and Mrs. James L. Wassell

Early interest has been great for the booths arranged by George Oakley to provide an equipment and services exhibition in The Drake during the Convention.

The postal announcement was mailed to all members on February 23. In addition to the general outline of technical sessions and papers, it provided the usual tear-off postal for making reservations at The Drake. And something new was added by Jim Wassell: a postal to be used by members for advance registration. It gives Registration Chairman Mason all the information so that a member's registration can be all ready, just waiting for him to step up and pay his fees.

The Advance Program, arranged by Program Chairman Heppberger and the Papers Committee, appears below.

Ken Mason, chairman for motion-picture short subjects, reports: Several films of unusual interest have been procured by the convention committee for showing at the technical sessions. Among these are:

Oddities in Farming, Reid H. Ray Film Industries
Highway by the Sea, Ford Motor Co.
500,000 to 1, Atlas Film Corp.
The Big Track, The Calvin Company
Pee Wee Reese, Emerson Yorke
It's All in Knowing How, Chicago Film Studios

Tentative Schedule of Committee Meetings During Convention

Monday, April 18
1:30 P.M. Film Dimensions

Tuesday, April 19
10:00 A.M. Color
10:00 A.M. Papers/78th Convention
1:30 P.M. PH22 *and* Standards, *joint meeting*

Wednesday, April 20
10:00 A.M. High-Speed Photography
1:30 P.M. Magnetic Recording
3:30 P.M. Sound

Thursday, April 21
10:00 A.M. Film-Projection Practice
1:30 P.M. Television
3:30 P.M. Television-Studio Lighting

Friday, April 22
10:00 A.M. Screen Brightness
1:30 P.M. 16 & 8mm

ADVANCE PROGRAM

A convention announcement with two return post cards, one for your hotel room reservation addressed to The Drake, and the other for advance convention registration addressed to Ken Mason, registration chairman, were mailed to the members on February 23. Here follows the Advance Program, giving the schedule of papers, sessions and special events.

The general line-up is set. But since a number of additional papers are not yet approved, a few minor changes will likely be made before printing the Final Program which you pick up at the Registration desk. If it's necessary to pinpoint your time for a single session or group of papers, better double check after the first week of April with Program Chairman C. E. Heppberger or his assistant, J. E. Moran, National Carbon Company, Financial 6-3300, Chicago, or with Society Headquarters.

CONVENTION EXHIBIT

Note that the convention includes as an added feature, an equipment exhibit scheduled to present the latest in motion-picture and television equipment by two dozen or more manufacturers and distributors. Exhibit booths will center in The Drake's Walton Room right next door to the Technical Sessions and will be open to all who register for the convention. All sessions will be held in the hotel, except the Friday morning one on VistaVision.

COMMITTEE MEETINGS

The 11 Engineering Committee meetings and the Papers/78th Convention committee meeting are listed above.

SMPTE 77th Convention
April 18-22 — Chicago

SUNDAY APRIL 17

Registration for the Convention will be opened in the afternoon in The Drake's French Room Foyer.

MONDAY APRIL 18

9:30 A.M., Convention Registration, The Drake's French Room Foyer

12:20 P.M., Get-Together Luncheon, with Guest Speaker Charles H. Percy, Gold Coast Room

3:00 P.M., SOUND SESSION

Some Practical Elements of 16mm Motion-Picture Sound Recording
ALLEN JACOBS, *The Calvin Company, Kansas City, Mo.*

Nomenclature from "engineer" through "specialist" to "production engineer" and their "tiers" of knowledge will be reviewed. Theoretical and practical knowledge to adequately evaluate and adapt research developments is required to approach the day-to-day job of recording sound. The theory of sound recording, including these factors — the original sound to be recorded, acoustical conditions, microphones, recording machines, recording materials and production techniques — is important to the degree it aids the improvement of motion-picture sound quality.

A Versatile 16mm Magnetic Recording System
R. W. CURTIS and R. J. BEAUDRY, *National Film Board of Canada, Ottawa*

The National Film Board of Canada has developed a versatile, two-case 16mm magnetic recording system which is intended for use on locations where the equipment carried must be kept to the very minimum. The mixer unit may be powered from either the line or from dry batteries, while the recorder unit, together with a suitable picture camera, may be supplied from a single 6-v vibrator source. Portability, flexibility of operation and high standards in recording quality have been attained in the system. The mechanical and electrical designs are fully described and the system is demonstrated.

Sound Effects Track Noise-Suppressor
J. F. BRYD, *Radio Corp. of America, Camden, N.J.*

A simplified noise-suppressor for the effects track in CinemaScope reproduction is described. The

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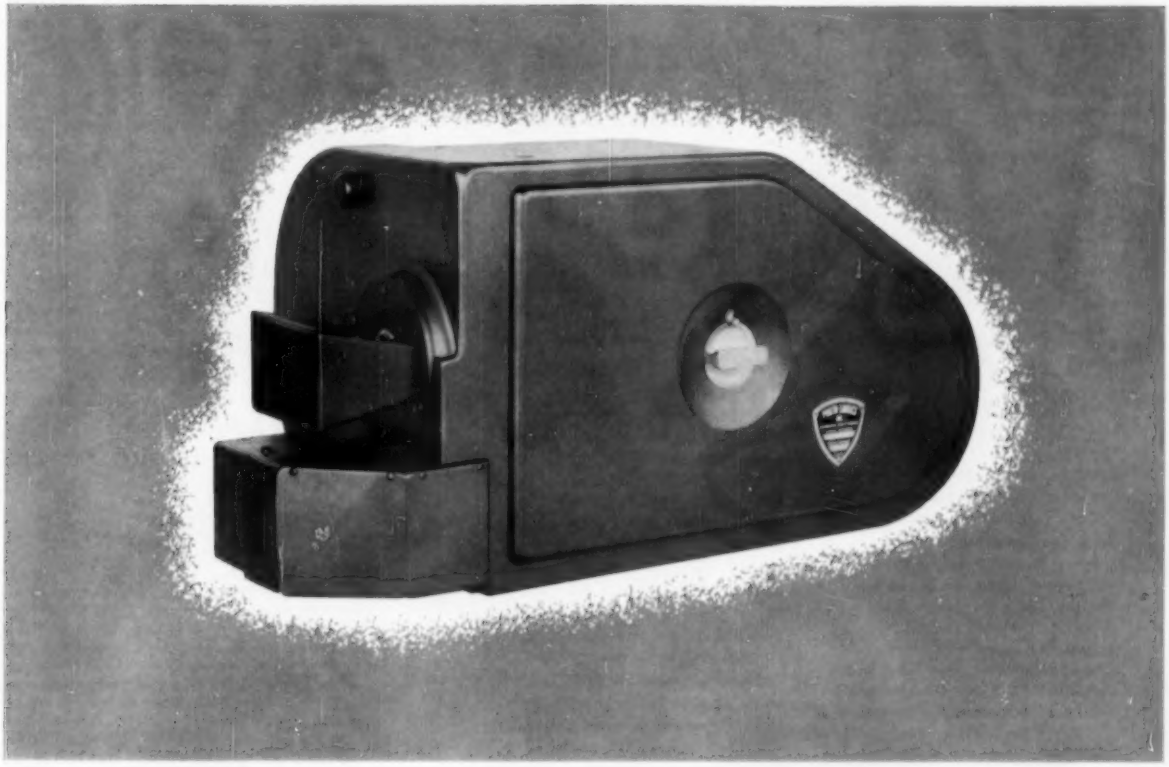

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FILM LOAD: 400 or 1000 ft. magazine

70MM-5A
For Aircraft Use
FRAME SIZE: 1.156 x 2.25 inches
MAX. FRAME RATE: 60 frames per sec.
FILM LOAD: 400 ft. daylight loading

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FRAME SIZE: 2.25 x 2.25 inches
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FILM LOAD: 400 or 1000 ft. magazine

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- Annual Volume of Advertising in U.S.
- Network TV & Radio Billings: 1949-54
- Revenues, Expenses and Earnings of TV-Radio Stations: 1946-53 (FCC)
- Top 100 Network Advertisers
- Television Status of U.S. Households
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- CPs Outstanding for New Stations
- With Probable Starting Dates
- Applications Pending
- TV Allocations Tables
- Television Stations by Call Letters
- Sales & Transfers of TV Stations
- Stations Which Have Gone Off Air
- Theatre-TV Organizations
- Subscription-TV Promoters & Firms
- Armed Forces TV Stations
- British Television Networks
- FCC TV Color Standards: Full Text
- FCC Technical Standards, as Amended
- Color Status of Network Stations
- TV-Radio Manufacturers: Financial Data
- Manufacturers of TV Receivers
- Picture & Receiving Tube Manufacturers
- Receiving Antenna Manufacturers
- Tuner & UHF Converter Manufacturers
- Phonograph & Record Manufacturers
- TV Set Production: Monthly, 1947-54
- TV-Radio Sales & Inventories: Monthly
- TV Shipments by States: 1950-54
- Cathode Ray Tube Sales: 1947-54
- Receiving Tube Sales: 1949-54
- Manufacturers of Telecasting Equipment
- RETMA: Executives & Committees
- Electronics Research Laboratories
- British TV-Radio Industry
- RCA: Officers and Executives
- CBS Inc.: Officers and Executives
- FCC Personnel Directory
- Attorneys Practicing Before the FCC
- TV-Radio Consulting Engineers
- Network Engineering Departments
- Miscellaneous Consulting Services
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unit operates in the speaker line, thus using the full gain of the system, and uses two tuned circuits: one accepts and rectifies the 12-kc control tone to operate a speaker relay, and the other rejects the 12-kc tone from the wanted program material in the effects speakers. The unit uses no tubes or power supply.

Status Report on Magnetic Sound Standards
E. W. D'ARCY, *Chicago*

Arricord 35, a New Double-System 35mm Camera
ROBERT RICHTER, *Arnold & Richter Co., Munich*
The Arricord 35 consists essentially of an Arriflex 35, Model IIa, camera with 400-ft magazine, mechanically synchronized with a magnetic recorder, also of 400-ft capacity, using 17½mm perforated film. The complete unit is housed in a compact sound blimp with external controls. Either a 110-v a-c synchronous motor or a governor-controlled d-c motor is used to drive camera and recorder simultaneously. Motors are readily interchangeable.

MONDAY EVENING

NONTHEATRICAL MOTION PICTURES

Film on Animation Techniques
JOHN OXBERRY, *The Animation Equipment Corp., New Rochelle, N.Y.*
A 35mm film (to be released in 16mm sound) has been made to demonstrate techniques of animation with the use of the Oxberry Stand and Compound. It employs live action and technical animation, using appropriate commercials to illustrate given features. Some of the techniques covered are: (1) fast live action effect zooms at low cost; (2) lots of action with few cels by bi-motion and tri-motion; and (3) free-wheeling with the use of a Pantograph Finder. The film also treats quality control and economy.

Two Animation Stands of New Design
E. H. BOWLDS, *E. H. Bowlds Engineering, Los Angeles*
This paper describes the design of two new stands for 16mm or 35mm single-frame or continuous photography of animated sequences. One stand features extremely flexible movements coupled with a precise system of calibrations. Provision is made for interchangeable, electrically operated platens for normal and oversize art work. For wide-screen processes, this stand is built to accommodate a special anamorphic lens. A second new model animation stand, of greatly simplified design to meet the demands of TV stations, industrial studios and non-theatrical producers, is also described.

Use of CinemaScope in 16mm Nontheatrical Films
JERRY FAIRBANKS, *Jerry Fairbanks Productions, Hollywood*
This paper deals with the problems encountered and the solutions in the filming of 16mm CinemaScope films for industrial and educational use. The methods of exhibition also are discussed.

Some Basic Elements of 16mm Projector Design
M. G. TOWNSLEY, *Bell & Howell Co., Chicago*
The basic elements which make up a 16mm motion-picture projector are identified and their purpose and essential characteristics described. Some of the design requirements which must be met in a successful projector are listed and typical performance values given.

Arc Lamps for 16mm Projectors
ROBERT S. FREEMAN, *Strong Electric Corp., Toledo, Ohio*
The use of arc lamps with 16mm projection equipment can extend the screen size, permit projection in rooms that cannot be entirely darkened, and allow greater picture detail to be

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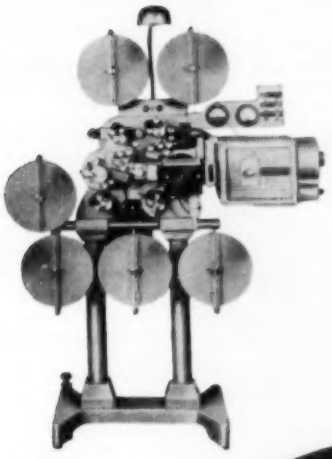

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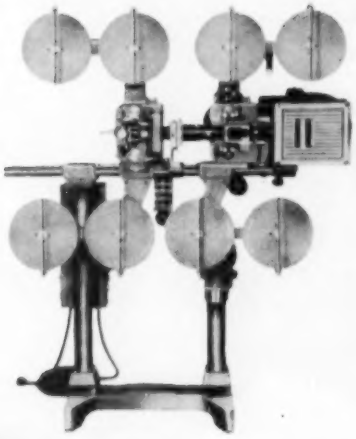

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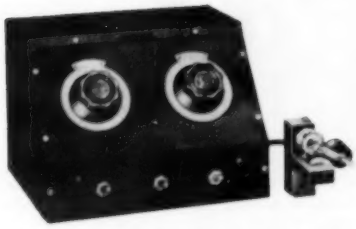

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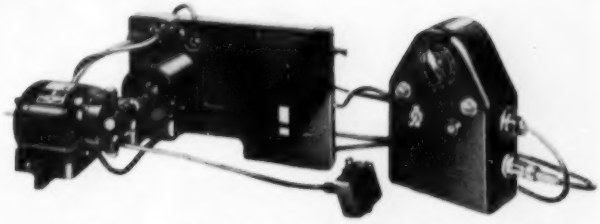

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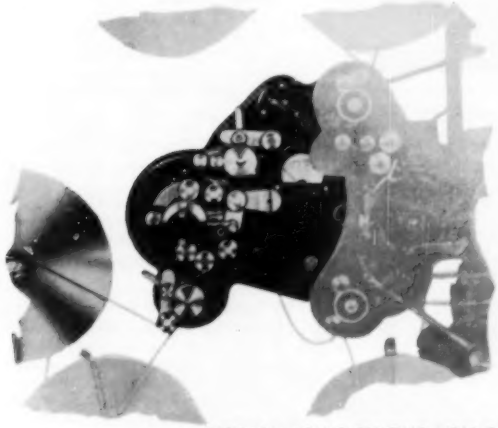

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observed due to the higher screen brightness. A brief description of the various arc lamps and their associated power supplies is presented in this paper.

Screens and Rooms
GERHARD LESSMAN, *Bell & Howell Co., Chicago*
Characteristics of commercially available screens are reviewed and their selection to suit some typical projection conditions is discussed. The effect of surrounds and ambient illumination is considered. Effective relationship of the screen instructor and seating arrangement is discussed. Desirable possible advances in screen design and their implications for future projection practices are then outlined briefly, with a note of caution regarding premature omission of ambient light control devices in classrooms.

TUESDAY MORNING APRIL 19
NONTHEATRICAL MOTION PICTURES

Film Cataloging at Moody Institute of Science
LEWIS H. HUMPHREY, *Moody Institute of Science, Los Angeles*
Because of the need of an extensive stock film library, Moody Institute of Science has developed a very effective classification and cataloging system. Modeled after the Dewey Decimal System used by public libraries, this system enables a cataloguer to group similar material and make it readily available to film editors with a minimum of effort.

Multiple Camera Control
IRWIN A. MOON and F. ALTON EVEREST, *Moody Institute of Science, Los Angeles*
In the photographic phase of certain types of motion-picture film production, multiple camera operation is of great economic value. This paper describes a simplified system by which three (or more) standard blimped cameras may, by pushbutton control, be started and stopped at will during sound takes with automatic head and tail synchronizing marks. Short cut editing procedures utilizing the film from such multiple camera operation are also described.

Selected Set Construction Techniques
HERBERT MEYER, *Motion Picture Research Council, Hollywood*
Motion-picture production on major studio lots has access to extensive fabricating facilities and know-how for the creation of sets, props and special effects. An attempt is made to aid those engaged in the production of commercial and educational motion pictures with their respective problems by supplying information regarding materials and processes selected to suit lower budgets, smaller facilities and lesser technical skills.

16mm Away From Hollywood
RUDY SWANSON, *Rudy Swanson Productions, Appleton, Wis.*
Due to the problems of equipment and personnel, located far away from large production centers, the independent producer must make good use of outstanding advances in 16mm equipment and techniques. The successful small film maker is a "do-it-yourself" expert, applying production advantages skillfully in the industrial field. High-quality product is essential for continued patronage from limited clientele.

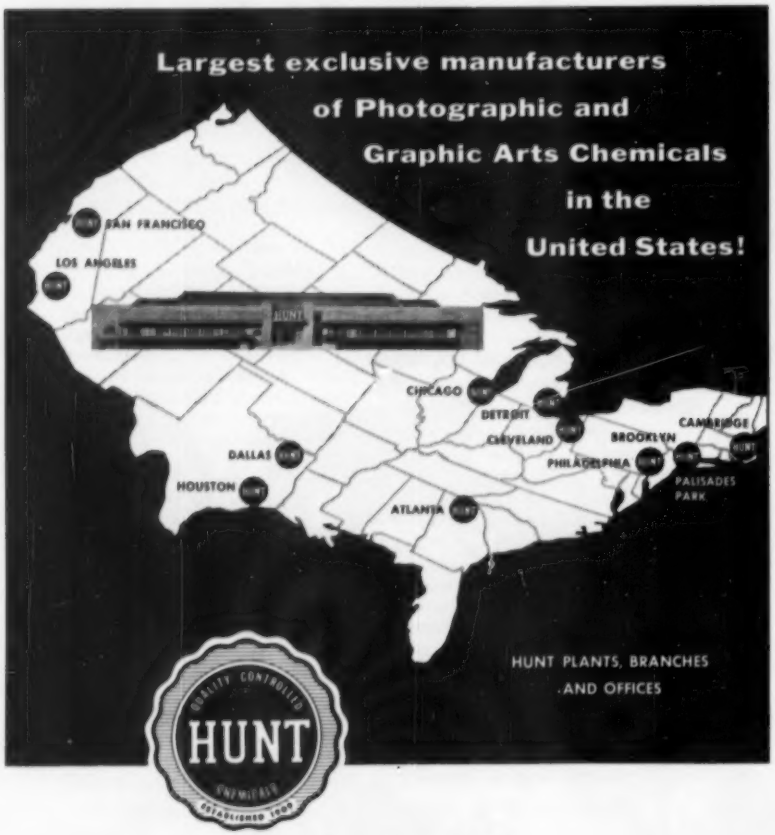
TUESDAY AFTERNOON
NONTHEATRICAL MOTION PICTURES

Analysis of Cost Characteristics of Business Motion Pictures
JOHN W. FLORY, *Eastman Kodak Co., Rochester, N.Y.*
This paper reports salient findings of a recent study by the Association of National Advertisers that provides heretofore confidential data on actual production, print and distribution costs, and methods, for advertising and public relations films produced by 67 leading companies. It gives a picture of the current costs of producing and circulating such a film; information about the type of films being produced, with target audiences, film size and type, number of release prints, average running time, etc.

A Survey of the Distribution of Nontheatrical Motion Pictures
HERBERT E. FARMER, *Dept. of Cinema, Univ. Southern California, Los Angeles*
Between the production of a motion picture and its availability for showing lies the very essential step of distribution or circulation by which the potential user learns of its availability and acquires it for his use. This paper briefly reviews the history and growth of the field of film distribution; analyzes the various channels and procedures used today by film distribution agencies; and surveys representative distributors, libraries and user groups correlating the business and fiscal policies under which their subjects are acquired and circulated.

Theory and Application of Pre-Production Testing for 16mm Nontheatrical Films
NICHOLAS ROSE, *Dept. of Cinema, Univ. Southern California, Los Angeles*
The 16mm nontheatrical film considered from the viewpoint of a communication device. A discussion of the theoretical aspects of a 16mm film as part of a communication situation. Some necessary considerations which need to be met for pre-production testing to be a valid prediction for the intended audience are indicated. Story board and non-story board pre-production models are discussed.

A Film Age for Education
P. A. JACOBSEN, *Univ. of Washington, Seattle*



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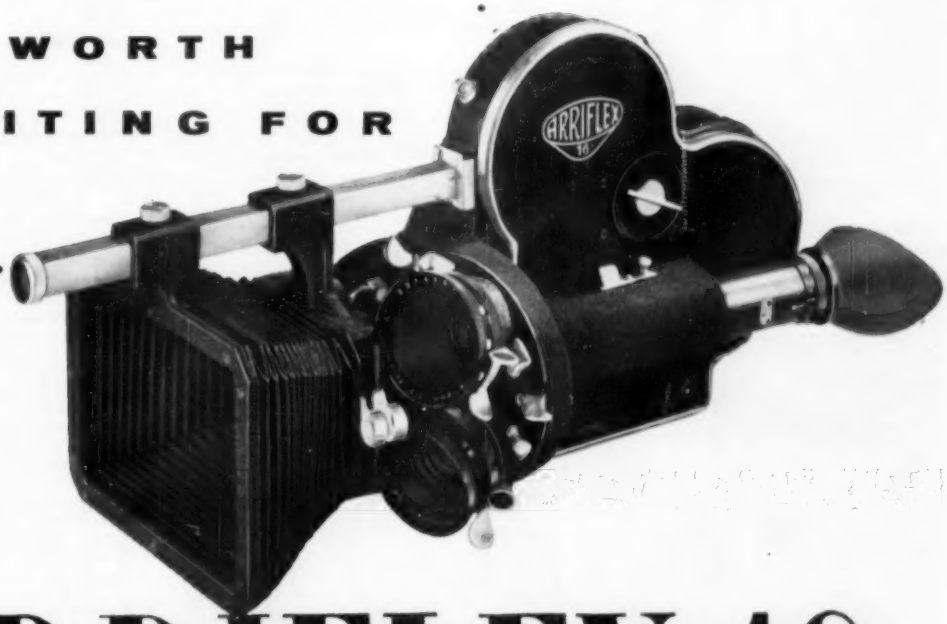

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A Film Age for Education
P. A. JACOBSEN, *Univ. of Washington, Seattle*

TUESDAY EVENING

NONTHEATRICAL MOTION PICTURES

Filming an Educational Television Series
REID H. RAY, *Reid H. Ray Film Industries, St. Paul*
Production techniques used in filming 39 half-hour television shows by a commercial film company are described. An educational-type program (originally televised "live," but not kinescoped) required a format unlike the entertainment television film. Studio set design, preproduction conferences, lighting, camera procedures, props, and special effects peculiar to these films are outlined in this paper.

Infrared Motion-Picture Technique in Observing Audience Reactions
BERNARD R. KANTOR, *Dept. of Cinema, Univ. Southern California, Los Angeles*
Taking infrared motion pictures of an audience while they are viewing a motion picture is feasible. This paper describes the theater installation necessary, the type of bulbs used, the preparation of a coating for these bulbs, specifications for exposure and development of the infrared film. The accompanying 16mm film shows the installations used plus examples of audience reactions.

How Walt Disney's Naturalist-Photographers Film Wildlife for the True-Life Adventures
ALFRED MILOTTE, *Walt Disney Productions, Burbank, Calif.*
How the famous wildlife photographers who help Walt Disney produce his True-Life Adventures carry out their field operations on the world's animal frontiers is explained in this report about their unique and exciting profession. It relates how these photo-naturalists and Disney's production team have opened up entirely new vistas on living creation for informative entertainment in the theater, television and nontheatrical fields.

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WEDNESDAY MORNING APRIL 20
TELEVISION

New 16mm Television Magnetic Optical Sound Projector for the Limited Budget
JOHN S. POWERS and GEORGE F. KRTOUS, *Bell & Howell Co., Chicago*
The increasing use of the vidicon camera as the pickup means in a television film chain has opened the field for a new 16mm magnetic and optical television projector designed for dependable high-quality picture and sound reproduction. This paper describes a projector suitable for film telecasting, using the vidicon camera.

Experimental Considerations for 8mm Kinescope Recording
GEO. W. COLBURN, *Geo. W. Colburn Laboratory, Inc., Chicago*
This paper describes a method for "canning" a half-hour television show in a space of $\frac{1}{2} \times 7 \times 7$ in., the picture and sound being recorded from an ordinary home receiver.

Low-Power Telecasting by the Armed Forces
LT-COL MEL WILLIAMSON and MAJ STANLEY E. RODBY, *Office of Armed Forces Information and Education, Dept. of Defense, Washington*
This paper discusses some of the problems and procedures connected with the establishment of low power telecasting by the Armed Forces for the entertainment, information and education of service personnel in isolated areas of the United States and in overseas areas where English language television programming is not available. It traces the development of the concept of Armed Forces Television and discusses "package" equipment requirements, programming, personnel requirements and costs of installation and training, with brief discussion of other aspects of television and its application to the Armed Forces.

Film Problems in Television Newscasting
SPENCER M. ALLEN, *WGN-TV, Chicago*
This is a semitechnical review of the problems confronting a television news editor who has had little or no experience with motion-picture film, and how he has learned to utilize the motion-picture art to develop a new type of journalism. It outlines the principal differences between old-style theater newsreel reporting and modern-day television news reporting. It points up some of the devices used in attempting to overcome the shortcomings of orthodox pan films, single-system soundtracks, developing and light problems, etc. It recommends needs and improvement in film techniques and associated equipment to keep up with the fast pace of the television art.

WEDNESDAY AFTERNOON
TELEVISION

Television Studio-Lighting Committee Report
H. M. GURIN, *Committee Chairman, National Broadcasting Co., New York*
Since the inception of the Television Studio-Lighting Committee, there has been considerable activity among the major television network broadcasters in attempting to codify terminology, measurements and equipment. More recently, the experience gained by smaller stations presents a fruitful source of information which should be utilized to the mutual advantage of the entire industry. Accordingly, steps are being taken to include their independent findings and submit an analysis and evaluation of the progress made as a committee effort for promoting the future growth and efficient utilization of television studio-lighting techniques. This report will outline the objectives of the committee and the proposed steps to achieve these aims.

Control of Light Intensity in Television Projectors
B. F. MELCHIONNI and K. SADASHIGE, *Radio Corp. of America, Camden, N.J.*
RCA's television projectors used with vidicon film cameras are equipped with a light-intensity

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control unit developed for this purpose. The unit is used to control the video output level of the camera by varying the intensity of the projector light source to compensate for varying film density. The angular position of a continuously variable neutral density filter wedge placed in the condenser lens system of a projector is remotely controlled by means of a servomechanism. Thus the signal-to-noise ratio of the system is maintained at its optimum value since the camera is operating with essentially constant input level.

A 35mm Motion-Picture Projector for Color Television

W. F. FISHER and W. R. ISOM, *Radio Corp. of America, Camden, N.J.*

A 35mm motion-picture projector for use with the three-vidicon film camera for color television is described. This projector employs a modified Geneva intermittent that permits long application of light and nonlocked synchronous operation. The light source is an incandescent lamp. Compensation for variation in film density, without affecting color balance, is provided. The unique accommodation of 24-frames/sec film rate to the 30-frame television system makes the projector adaptable for all storage and semi-storage film pick-up systems.

Chromacoder Colorcasting

PIERRE H. BOUCHERON, JR., *General Electric Co., Syracuse, N.Y.*

Briefly explained are the sequential camera and controls, with scanning rates of three times NTSC rates and at right angles to normal raster, scan rate and sequential to simultaneous conversion in an RBG chromacoder, and the C.P.S. Emitron pickup tube, its operation and advantages. The luminance, or RBY, chromacoder gives freedom from registration in the black-and-white picture and reduction of the registry problem in color picture.

Experimental Equipment for Recording and Reproducing Color-Television Images on Black-and-White Film

WILLIAM L. HUGHES, *Engineering Experiment Station, Iowa State College Ames, Iowa*

At the National Institute of Radio Engineers Convention in 1954, a system of recording and reproducing color-television images on black-and-white film was proposed. The system made use of a combination color separation and electronic switching principle. Provisions were made in the system design for kinescope recording, recording live scenes with a mechanical camera, and reproduction of color-television images directly from black-and-white film with a simple flying-spot scanner. At the time the system was proposed, it had not been tried. This paper is a detailed account of the construction and preliminary operation of the proposed system which has now been operated successfully.

Characteristics of the "Perfect" Lens and the "Perfect" Television System

OTTO SCHADE, *Tube Dept., Radio Corp. of America, Harrison, N. J.*

A "perfect" image is defined optically as an image in which the light-intensity distribution is determined by diffraction alone. In this case the finite boundary (lens stop) of a lens acts as a low-pass filter which determines the sine-wave spectrum of the perfect lens. A perfect television system can hence be defined as a system in which the performance is limited only by the electrical cutoff filter of the system and the optical filter requirements imposed by the raster process. It will be shown that the performance of a "perfect" TV system differs in many ways from that of a perfect lens and photographic system and that a close approach to its performance is possible with practical systems.

WEDNESDAY EVENING

TELEVISION

Color Television Vs. Color Motion Pictures

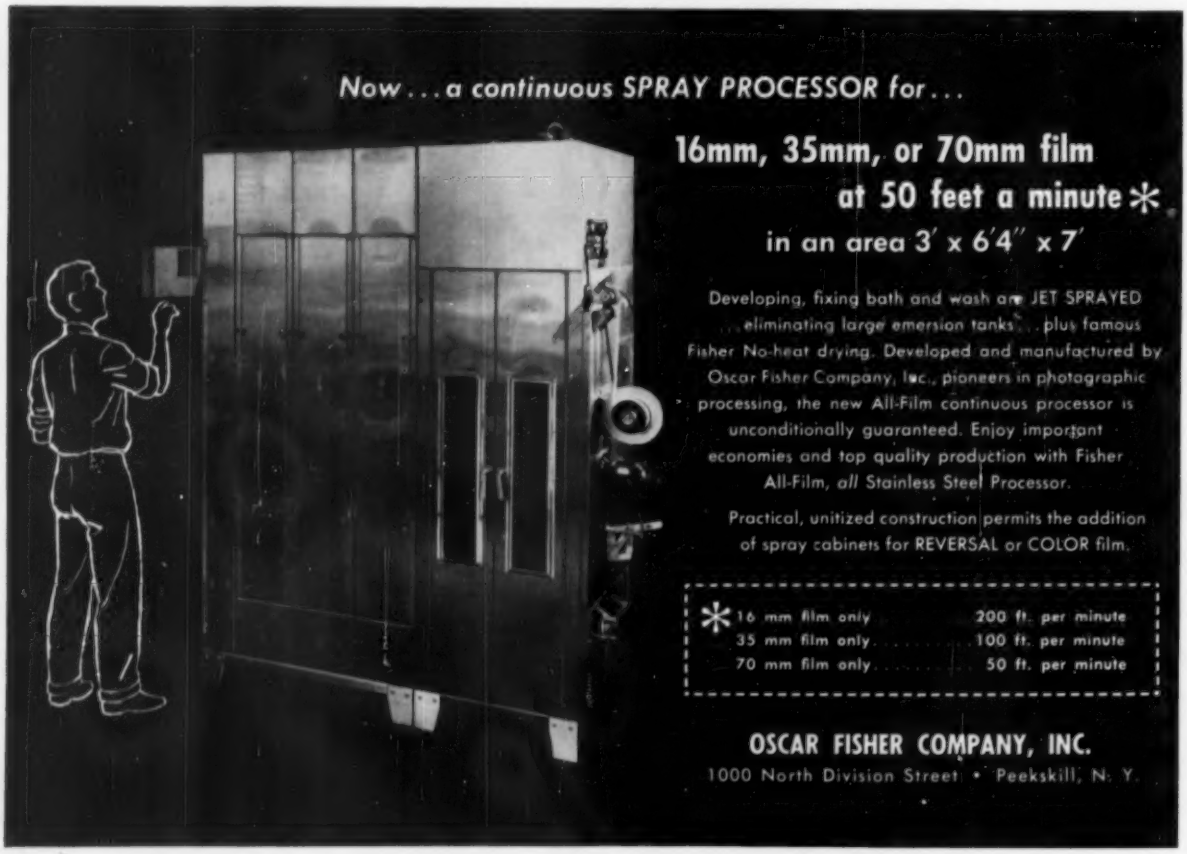
DONALD G. FINK, *Philco Corp., Philadelphia*

The technical capabilities and limitations of color television and color photography are compared in five categories: (1) the viewing situation, (2) image photometry, (3) image colorimetry, (4) image structure and (5) image continuity. The results of a detailed survey of the practices of motion-picture theaters and the 8mm and 16mm home movie systems are compared with the current performance obtained by 21-in. color-television receivers. Tables comparing these systems are presented. The avenues open to television and photographic engineers to improve the respective systems are pointed out.

Integration of Color Television Equipment in a Television Station

PHILLIP B. LAESER, WTMJ-TV, *The Milwaukee Journal, Milwaukee*

WTMJ-TV's pioneer color installation and the operational problems faced by its engineers during the past 16 months are discussed. The results and experience gained by integrating color film slides and live color camera equipment with the present monochrome system are given. The scope of the discussion includes some of the technical difficulties and handling of the color signals from the camera to studio control room through the master and TV transmitter. Color test procedures, lighting, air-conditioning and manpower requirements at the station are also explained and illustrated.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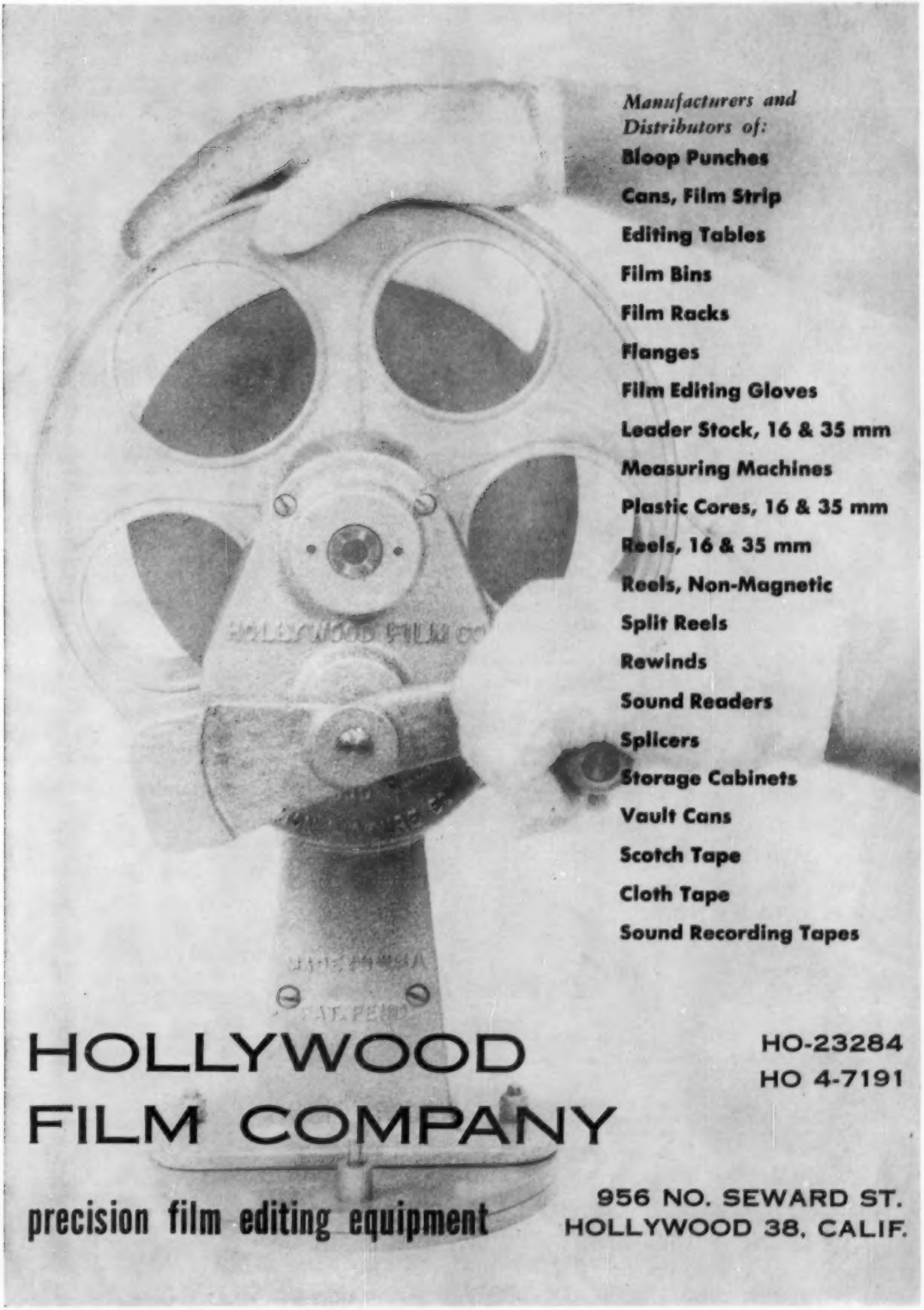
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THURSDAY MORNING APRIL 21

CONCURRENT SESSIONS

LABORATORY PRACTICE

The Role of Resolving Power and Acutance in Photographic Definition

G. C. HIGGINS and R. N. WOLFE, *Eastman Kodak Co., Rochester, N.Y.*

Experiments have shown that no unique correlation exists between either resolving power or acutance and definition, which is the quality aspect of a photograph associated with the clarity of detail. Acutance was found to correlate with definition when resolving power was above that for the eye under the conditions for which the prints were viewed, and to correlate with definition in all cases when it was weighted by a suitable function of resolving power and viewing conditions.

The Effect on Definition of the Stage at Which Reduction Is Performed in Reduction-Printing Processes

G. C. HIGGINS, R. L. LAMBERTS and R. A. PURDY, *Eastman Kodak Co., Rochester, N.Y.*

When reduction prints are made by a process involving duplicating positives and negatives, the size reduction can be made at any convenient stage. Color prints have been prepared from color negatives at a reduction of two to one, the reduction being made at a different stage for each print. The prints were ranked for definition. These prints will be shown and the conclusions of the study discussed.

Depth of Field and Perspective Considerations in Wide-Screen Cinematography

R. N. WOLFE and F. H. PERRIN, *Eastman Kodak Co., Rochester, N.Y.*

To improve definition in wide-screen cinematography, negatives are often made with a frame size larger than normal. This results in decreasing the depth of field by an amount that depends on whether the camera position or the focal length of the lens is changed. The effects of the various factors on the depth of field and perspective will be discussed and illustrated.

HIGH-SPEED PHOTOGRAPHY

Cameras for Underwater

HAROLD E. EDGERTON, *Massachusetts Inst. of Technology, Cambridge, Mass.*, and LLOYD D. HOADLEY, *Woods Hole Oceanographic Inst., Woods Hole, Mass.*

The design of underwater automatic and controlled cameras is discussed. A camera of linear design uses a 4-in. (ID) cylinder and a standard 100-ft roll of 35mm film, exposing 800 frames of double 35mm size. Electronic flash is used for illumination, either synchronized with a shutter when external light is present, or without a shutter in darkness. Simplified calculations are given in chart form for cylinders and end plates with external pressure. A few experimental points are given.

Sensitometer With Electronic Flash Illumination

CHARLES W. WYCKOFF and HAROLD E. EDGERTON, *Edgerton, Germeshausen and Grier, Boston*

A sensitometer is described, which uses the electronic flashtube for illumination, using circuits of variable constants to obtain exposure times, in the range from 8000 to 280 μsec. The electronic flash system requires no rotating mechanism or shutter. The spectral distribution of the xenon discharge is a very good approximation to that of daylight. The quantity of radiation per flash is remarkably constant.

A New Schlieren System for High-Speed Photography

RAY CHRISTENSEN and B. F. BECKELMAN, *Boeing Airplane Company*

A New High-Speed 16mm Framing Camera

F. W. WARRICK, *Frederick P. Warrick Co., Bloomfield Hills, Mich.*

High-Speed Photography of Solar Surfaces

JOHN WADDELL, *Rochester, N.Y.*

Controlled Tests to Evaluate the Accuracy of Accelerations Derived From Analysis of High Speed Camera Film Using a Bausch & Lomb Optical Comparator

D. M. SEVERY and PAUL BARBOUR

High-Speed Photography of Business Machines

NATIONAL CASH REGISTER COMPANY

THURSDAY AFTERNOON

CONCURRENT SESSIONS

LABORATORY PRACTICE

Effect of Nitrogen Oxide Gases on Processed Acetate Film

J. F. CARROLL and J. M. CALHOUN, *Eastman Kodak Co., Rochester, N.Y.*

Safety motion-picture film on cellulose acetate base has been found chemically damaged on occasion by storage in the same can with unstable nitrate film. As a result, the effects on acetate film of the three nitrogen oxide gases produced by the decomposition of nitrate film have been investigated. Nitrous oxide and nitric oxide were found to be harmless, but nitrogen dioxide, even at low concentrations, is seriously damaging to safety film. This is to be expected, since nitrogen dioxide reacts with moisture to form nitrous and nitric acids. The order in which the film components are attacked by nitrogen dioxide is: the silver or dye image first, the gelatin of the emulsion second, and the acetate base last. The rate of attack increases with increase in relative humidity. It is concluded that safety films should never be stored in the same can with nitrate films and preferably not in the same room.

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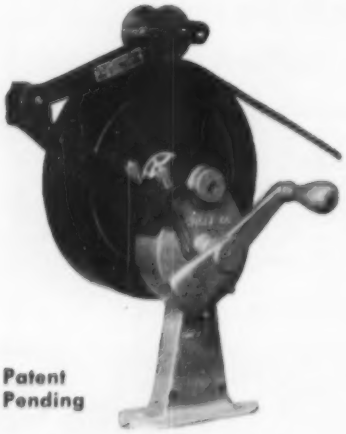

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Recent Developments in Magnetic Striping by the Lamination Process
RICHARD F. DUBBE, *Minnesota Mining & Manufacturing Co., St Paul, Minn.*
A new machine for the application of a magnetic stripe to 16mm and 8mm motion-picture film by a lamination process is discussed. The machine incorporates several new developments such as improved slitting, adjustable track position, a pre-size coater, and a humidity cabinet with elevator. These improvements have made dependable striping on both the base and emulsion surface of the films possible and permit removal of the cellophane carrier in one operation.

A Comparison of Soundtrack Processing Methods for Color Release Positive Film
JOHN L. FORREST, *Ansco, Binghamton, N.Y.*
The problems of processing color release positive film to give a dye image and a silver soundtrack are discussed. The viscous image bleach method is described in some detail. The direct silver plus dye track produced by the viscous bleach method is compared with the track produced by the conventional redeveloped silver method.

A Multiple Magnetic Printing Equipment for CinemaScope
HANS-CHRISTOPH WOHLRAB, *Siemens and Halske A.G., Karlsruhe, West Germany*
A high-speed CinemaScope four-track sound printing equipment that produces six prints at the same time has been developed by the Klangfilm Division of Siemens and Halske A.G., Karlsruhe, Western Germany, to meet specifications of DeLuxe Laboratories, Inc., New York. The printer operates at a speed of 135 ft/min, and, serviced by two men, has a printing capacity of 30,000 ft/hr.

Summary of Proposed Laboratory Standards of the Association of Cinema Laboratories
BYRON ROUDABUSH, *Byron, Inc., Washington*

Single-System Printing Device for Bell & Howell Model "J" Printer
ROBERT VANCE, *Byron, Inc., Washington, D.C.*
The Bell & Howell Model "J" Printer has been adapted to permit the printing of single-system picture and soundtrack simultaneously, at the same aperture, from the regular single light source, yet allowing conventional light changes without causing variations in soundtrack exposure.

The Logatronic Printing Principle for Television Release Prints
D. R. CRAIG, *President, Logatronics, Inc., Washington, D.C.*

Model "D" and "J" Printer Improvements
A. C. MUELLER, *Bell & Howell Co., Chicago*
General description of the following improvements: (1) double-head printing attachment; (2) sensitized cuing patch; (3) edge printing attachment; and (4) automatic fading device.

HIGH-SPEED PHOTOGRAPHY

The listing of papers and demonstrations for this session will be part of those listed on this morning's High-Speed Photography Session.

THURSDAY EVENING

COCKTAIL HOUR, then BANQUET AND DANCE (Informal, dress optional)

FRIDAY MORNING APRIL 22

WIDE SCREEN and VISTAVISION

Reliability Engineering
C. M. RYERSON, *Radio Corp. of America, Camden, N.J.*
Recent advances in the field of "reliability engineering" are reviewed. These include specialized work in four areas: equipment reliability, component reliability, design and use aspects, and reliability program administration. The present status of equipment and part reliability is reviewed, and facts are given on measurement methods and their results. Reliability calculation and prediction are touched upon. Slides are shown, simplifying the presentation and illustrating the results described.

An Aspheric Lens for Mirror-Type Motion-Picture Projection Systems
R. E. HARRINGTON, *National Carbon Co., Cleveland*
An aspheric lens is described which is designed to be added to the elliptical mirror-type of projection optical system commonly employed with carbon-arc light sources. The added aspheric lens reduces the effect of the inherent foreshortened images of the crater formed by the outer zones of an elliptical mirror of large collection angle. Measurements of screen light color and distribution obtained using a sample aspheric lens will be discussed.

This session will be held in a theater, with additional papers and demonstrations.

FRIDAY AFTERNOON

WIDE SCREEN and SCREEN BRIGHTNESS

Historical Notes on Large Screens, Wide Screens and Cycloramas; Some Little-Known Facts
JULIUS B. POSTAL, *Tele-Science Productions, New York*
An anecdotal history of "large" screens, "wide" screens, cycloramas, panoramic triple-projection screens and the like, from 1892 to the present, in which it is shown that the enhanced screen idea is almost as old as the commercial motion picture itself.

Evaluation and Reaction to New Processes of Motion-Picture Presentation
LUCIEN E. POPE, *Fox Midwest Amusement Corp.*, and RICHARD H. OREAR, *Commonwealth Theatres, Inc., Kansas City, Mo.*
A retrospective review of the problems involved in the conversion of many theaters for the various methods of motion-picture presentation is made. Patron acceptance influences management justification for required modifications for these newer processes. The authors have faced problems of equipping over 200 theaters for the changed presentation processes.

Ambient Light From Motion-Picture Projectors
JOHN R. MILES, *John R. Miles Co., Skokie, Ill.*
Motion-picture illumination is not produced by classical condensers, but rather by source-imaging systems, which have specific characteristics limiting the light on the screen edge. Some of these characteristics are often produced by using short-focus lenses with a mirror designed for long-focus lenses. This produces difficulties which are not completely overcome by faster lenses. Tube spaces in projectors, meant for long-focus lenses, also frequently produce uneven illumination.

A report of the Screen Brightness Committee and other papers are planned for this session.

LADIES PROGRAM—In addition to the usual invitation to attend the Get-Together Luncheon on Monday and of course the Cocktail Hour, Banquet and Dance, a local activities and entertainment program is being arranged by Mrs. Geo. W. Colburn and Mrs. Malcolm G. Townsley, as Cohostesses. The Hospitality Committee under Geo. W. Colburn will have available tickets and suggestions for many Chicago activities. Passes for motion-picture theaters downtown and near The Drake will be available.

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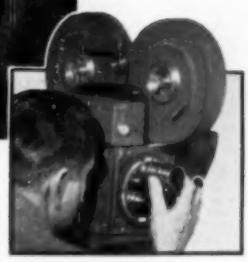

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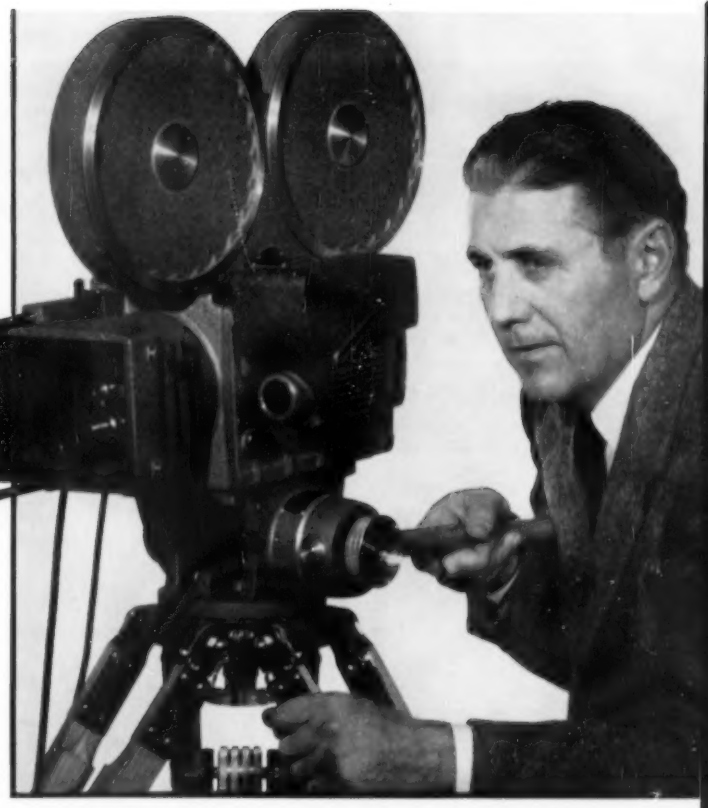

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section reports

First Meeting Western New York Subsection

An opportunity to compare simultaneously color television, black-and-white television from the color TV signals, and a projected image of a 35mm color print was offered to 375 people who attended the first Western New York Subsection meeting on January 26 in the main auditorium of Rochester's Radio City. The group saw the "Norby" television show, sponsored by Eastman Kodak and color telecast by NBC in New York City from 35mm color film.

Through the cooperation of WHAM-TV (Rochester), which donated its auditorium and facilities, and NBC, a telephone line was kept open during the show from the auditorium in Rochester directly to the NBC Master Control in New York City. On cue from NBC the Rochester staff was able to project a 35mm color print of the same program simultaneously with the telecast. So the projected print would be in synchronism with the telecast print, John Stott had previously cut the commercials into the print from footage numbers telephoned from NBC.

While synchronism was not perfect throughout the show, it was never more than two seconds out, and generally much closer. The color telecast was viewed on a 14-in. tube, the black-and-white picture on a 21-in. tube, and the 35mm color print was rear-projected at 3 × 4 ft.

After the demonstration, Gentry Veal of the Kodak Research Laboratories introduced the speakers for the evening. First, John Barstow, Director of Television Distribution for Bell Telephone Laboratories, discussed the problems of transmitting and switching TV broadcasts over long lines. He explained that while Rochester is generally served near the end of a 2600-mile loop going through St. Louis and Chicago, in this case it was served by a shorter microwave route 300 miles long coming through Albany and Syracuse. Mr. Barstow was followed by Kenneth Gardner, Director of Engineering for WHAM-TV, who explained what must be done with the signal as received in order to transmit it locally to best advantage.

The group was congratulated by Axel G. Jensen, Engineering Vice-President of SMPTE, on their courage in attempting such a difficult public experiment. He, and no doubt others, had made such comparisons in company privacy, but not in front of an audience. Mr. Jensen thought the color in the test was beautiful, though it showed that there is still difficulty in obtaining a good, saturated red.

E. P. Genock, Chairman of the Subsection's Nominating Committee, announced the names of the new subsection officers, who had been elected by letter ballot. They are: John G. Stott, Chairman (Eastman Kodak); A. C. Robertson, Secretary-Treasurer (Eastman Kodak); John H. Waddell, Program Chairman; David D. Manning (WHAM-TV) and Monroe H. Sweet (Consultant), Board of Managers, 2-yr term; and Arthur E. Neumer (Bausch & Lomb) and William J. Morlock (General Electric), Board of Managers, 1-yr term.

The need for a new SMPTE subsection in Western New York (which includes the Binghamton, Buffalo, Rochester and Syracuse areas) had been discussed about a year ago by members in this area. Not only does this region have several photographic and electronic manufacturing plants, but it also has active television enterprises which employ many motion-picture and television engineers. In fact, this area ranks just behind Hollywood, New York and Chicago in size, having over 225 Society members. Consequently a petition to form a subsection was presented to the Board of Governors and permission was granted on October 18, 1954.

The next meeting of the local section is scheduled for March 9, 1955.—*John G. Stott*, Chairman, c/o Color Technology Div., Eastman Kodak Co., Kodak Park, Bldg. 65, Rochester 4, N.Y.

The **Pacific Coast Section** held a double-session meeting February 22 on VistaVision at Paramount Studios for 350 members. Vice-President Y. Frank Freeman welcomed members to Paramount. A demonstration and discussion of various methods of VistaVision projection in the theater were conducted by Loren Ryder, head of Engineering and Recording at Paramount. In a selection from *Vagabond King* a standard vertical projection print in Eastman

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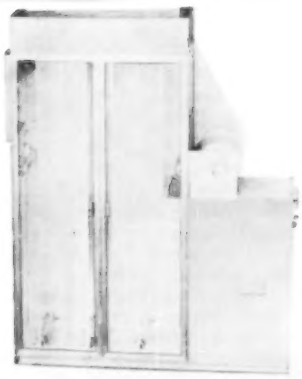

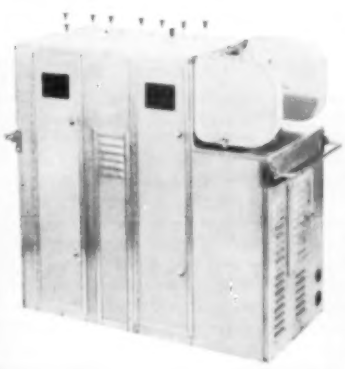

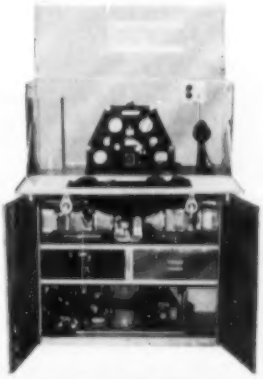

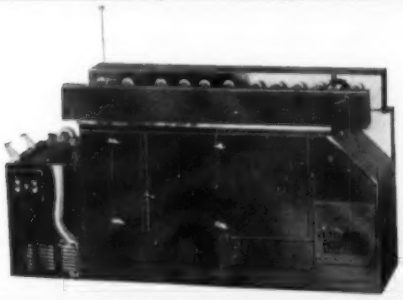

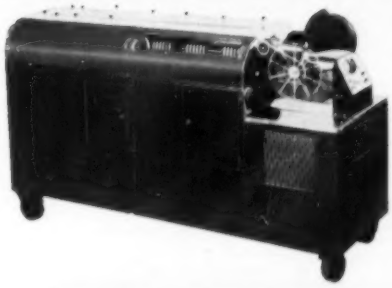

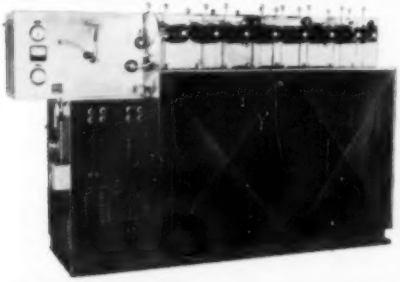

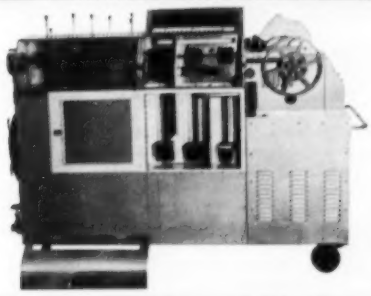

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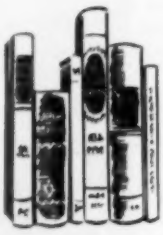
Color, made by reduction from the VistaVision double-frame negative, was projected with composite magnetically striped stereophonic sound; other samples were then projected from a double-frame VistaVision print. Mr. Ryder pointed out the stereoscopic effect due to the very sharp definition from foreground to background and to a modification of framing during projection. Movement of the camera and of action in the picture were also controlled to add further to the illusion. The VistaVision process, Mr. Ryder said, could be used with optically squeezed pictures on either the vertical standard or double-frame print; and special recording methods, including 6-channel magnetic, could be accommodated. For the final demonstration the "Champagne" number from *Girl Rush* was projected from a standard vertical print with single photographic Perspecta Sound.—*E. W. Templin*, Secretary-Treasurer, c/o Westrex Corp., 6601 Romaine St., Hollywood 38.

The **San Francisco Subsection** at its December meeting elected:

Leo Diner, *Chairman*
Glen Pew, Vice-Chairman,
R. A. Isberg, Secretary-Treasurer.

The meeting topic was a live color-television camera demonstration by Lee Berryhill, Chief Engineer of KRON-TV, assisted by Roger Woodruf, Doran Ford and Granville Esch who are engineers at KRON-TV.

The first meeting for 1955 was held on February 3 at Leo Diner's film studio in San Francisco. The speaker of the evening was J. Joe Meyer, West Coast Manager of the Wollensak Optical Co. He described the Wollensak plant and showed films of the manufacture of lenses. He displayed several lenses, including the Wollensak 20- and 40-in. telephoto lenses which use mirror optical elements. He showed several films made with the Fastax camera and demonstrated it by running 100 ft of 16mm film through in six tenths of a second.—*R. A. Isberg*, Secretary-Treasurer, 2001 Barbara Dr., Palo Alto, Calif.



books reviewed

Theatre Catalog, 12th Annual Edition, 1954–1955

Published (1954) by Jay Emanuel Publications, 246-48 N. Clarion St., Philadelphia 7. i-xxxii + 410 pp. Profusely illus., includes advtg. 9¼ × 12¼ in. Price $5.00 (foreign shipments $10.00 a copy).

This year's *Theatre Catalog* reflects the optimistic spirit of the theater industry as it leaves yesterday's box-office clash with home television and, armed with superior projection and sound techniques, enters a new period marked by public enthusiasm for wide screens and quality films.

Theatre Catalog is an impressive encyclopedia on theater business, including design, construction, equipment and facilities, maintenance, and management. Among the many subjects covered are: new construction materials, lighting, CinemaScope installation, Paramount's VistaVision, screen materials, air conditioning, network theater television, new products, concessions and drive-ins.

This year's editorial feature is devoted to a history of the SMPTE's growth and service to the entire industry, illustrated by photographs showing the progress made in equipment from Edison's 1889 Kinetograph to RCA's experimental magnetic-tape video recorder.

Sound recording and reproduction systems are well described. An excellent article by William Snow provides clarification and classification of stereophonic techniques, past and present.

There is a comprehensive review of domestic and foreign theater design. One article describes the status of the film industry in postwar Japan. As in all other articles, the illustrations are well chosen. A complete cumulative index to advertising and articles of interest makes each year's *Theatre Catalog* continuingly useful.—*Rowland H. Müller*, General Precision Laboratory Inc., Pleasantville, N.Y.

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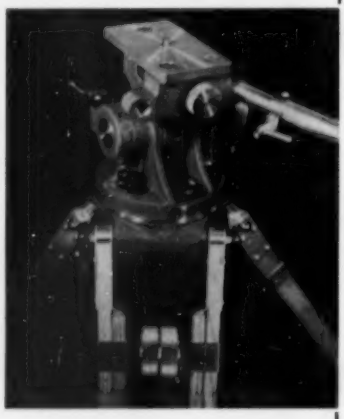

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current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer

vol. 35, July 1954

Cukoloris—Set Lighting's Most Versatile Tool (p. 332) *J. Lashelle*
Tri-X—New Eastman High-Speed Negative Motion Picture Film (p. 335) *E. Huse*
Creative Cutting (p. 336) *C. Loring*
Simultaneous Production Shooting in CinemaScope and Wide-Screen (p. 338) *G. Folsey*
Case History of a Non-Theatrical Film Production (p. 342) *C. L. Anderson*
Arriflex Cameras Adapted for CinemaScope (p. 344) *A. Rowan*
Hot Splicer Conversion (p. 348) *H. Stockert*

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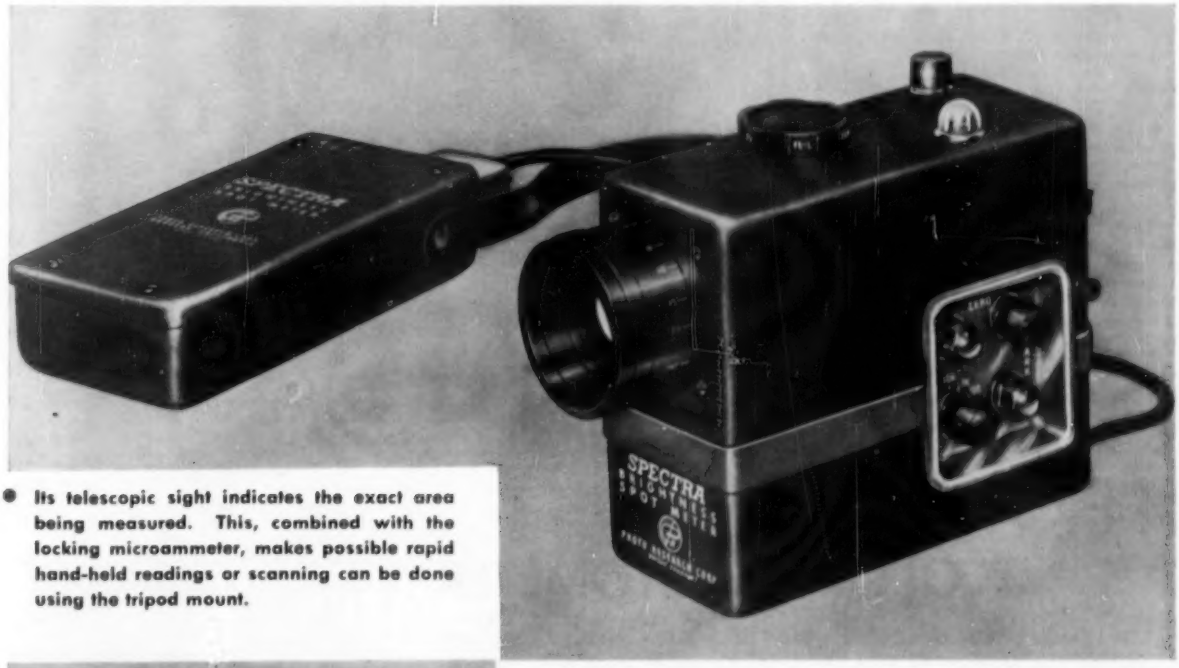

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Technical Progress in 1954 (p. 24) *A. E. Gavin*

Adapting the Zoomar Lens to the Auricon-Pro (p. 28) *J. Hoke*

Low Budget Training Film Production (p. 30) *A. H. Smith*

Tri-X in Feature Film Production (p. 33) *S. Cortez*

Movies without a Camera (p. 34) *H. Benson*

Audio Engineering Society, Journal

vol. 2, No. 3, July 1954

Survey of Flux-responsive Magnetic Reproducing Heads (p. 145) *O. Kornei*

The Mechanics of Good Loudspeaker Design (p. 176) *A. B. Cohen*

Bild und Ton vol. 7, Dec. 1954

Die kinematographische Beobachtung von Sonnenfinsternissen (p. 359) *D. Wattenberg*

British Journal of Applied Physics

vol. 5, Dec. 1954

High Current Spark Channels (p. 446) *J. E. Allen and J. D. Craggs*

British Kinematography vol. 25, Sept. 1954

Dynamic Focussing of Motion Picture Cameras (p. 72) *R. L. Hoult*

The New Chromart-Tricolor Separation Negative Material and Process (p. 79) *H. von Fraunhofer*

Dimming Fluorescent Tubes in the Cinema (p. 81) *H. H. Ballin*

vol. 25, Oct. 1954

Electronic Film-making (p. 104) *T. C. Macnamara*

Experimental Colour Television (p. 107) *Marconi Company*

Some Problems of Sound Reproduction (p. 118) *F. H. Brittain*

vol. 25, No. 5, Nov. 1954

The Specialized Film (p. 138) *H. S. Hind*

The Use and Abuse of Film in Medical Illustration (p. 148) *R. Ollerenshaw*

vol. 25, No. 6, Dec 1954

New Studio Techniques at Highbury (p. 169) *T. C. Macnamara, W. D. Kemp, A. M. Spooner, B. R. Greenhead and N. Q. Lawrence*

Lighting for High Speed Photography (p. 183) *P. T. Cahill*

vol. 26, Jan. 1955

Recent Developments in Colour Television with Special Reference to the Field-Sequential System (p. 5) *I. J. P. James*

The Techniques of Large Screen Presentation, Pt. II (p. 21)

Electronics vol. 27, Aug. 1954

Adjustment Procedures for Color TV Production (p. 140) *C. T. McClane*

Continuous Film Scanner for Monochrome or Color (p. 152) *E. H. Traub and J. F. Fisher*

vol. 27, Dec. 1954

Sine-Squared Pulses Test Color-TV Systems (p. 138) *R. C. Kennedy*

vol. 28, Feb. 1955

Phase Measurement for Color TV and F-M (p. 142) *K. Schlesinger*

Infrared Speeds Erasure of Dark-Trace Tubes (p. 170) *F. Holborn and G. Hodowanec*

Ideal Kinema vol. 21, Jan. 13, 1955

Characteristics of Anamorphic Optics (p. 14) *G. H. Cook*

How the Delrama Mirror System Works (p. 21)

Stereophonic Sound System for Small Kinemas (p. 23)

British-made Perspecta Integrators (p. 24)

Industrial Photography

vol. 4, Jan.-Feb. 1955

Drum Camera Monitors Friction Research (p. 40) *J. J. Barton, H. G. Clarke, Jr. and W. W. Shugarts, Jr.*

Institute of Radio Engineers, Proceedings

vol. 43, Jan. 1955

Color Balance for Television (p. 11) *D. L. MacAdam*

Comment on "NTSC Signal Specifications for Color Television" (p. 100) *W. L. Brewer and J. H. Ladd*

International Projectionist

vol. 29, July, Section 2, 1954 (Convention Edition)

Prescription for Good Projection (p. 7) *B. T. Wedmore*

The Carbon Arc: Vital Twin Factor in Production and Projection (p. 14)

Flexibility Marks Modern Arclamps (p. 19) *A. J. Hatch*

VistaVision: Basis for a World-Wide Standard of Presentation (p. 23) *L. L. Ryder*

Evolution of the Simplex Projector (p. 30) *E. B. Garrison*

Perspecta—The All-purpose Recording and Reproducing Sound System (p. 32) *R. Fine*

From Magic Lantern to Giant Screen Stereo Sound (p. 34) *H. T. Matthews*

vol. 29, Nov. 1954

Wide-Screen Presentation Magnifies Inherent Projection Defects (p. 7) *R. A. Mitchell*

From Toy to a Great Industry (p. 15) *J. E. Gieck*

TransVerteR: Source of Flickerless Arc Power (p. 17) *W. Smart*

Giant Picture from 16-mm Film (p. 22)

vol. 29, Dec. 1954

Wide-Screen Presentation Magnifies Inherent Projection Defects (p. 7) *R. A. Mitchell*

VistaVision Process on the Move (p. 12) *L. L. Ryder*

Air Blast, Water-cooling Joined in New Conversion Unit for Simplex X-L (p. 13)

Elements of Optical Condensing Systems (p. 23) *A. E. Murray*

From Toy to a Great Industry (p. 30) *J. E. Gieck*

vol. 30, Jan. 1955

Light Sources for Film Projection (p. 7) *R. A. Mitchell*

1954: Decisive Year for Film Industry (p. 11) *J. Morris*

From Toy to a Great Industry (p. 15) *J. E. Gieck*

Kinematograph Weekly

vol. 453, Dec. 16, 1954

This is the Era of Wide-screen Films in Colour (p. 109) *T. Howard*

Filming by Electronic Processes (p. 111)

The Principles of Ferraniacolor (p. 112)

Laboratory Services (p. 115) *R. H. Cricks*

New Equipment and Services (p. 119)

Balancing Tints to Deceive the Eye (p. 131) *R. W. G. Hunt*

Black and White Treatment for Gevacolor Stocks (p. 131)

Field-sequential System Characteristics (p. 133) *I. J. P. James*

Viewers for Split-frame Stereoscopic Films (p. 167) *C. Burns*

Kino-Technik vol. 8, July 1954

Grundsätzliches zur magnetischen Bildaufzeichnung (p. 202) *C. Möller*

Der Film als wertvoller Helfer der Fernsehtechnik (p. 204) *W. Behrendt*

Schmalfilm mit Magnetton im Südwestfunk-Fernsehbetrieb (p. 204) *H. Lauer and O. Schulze*

vol. 8, Oct. 1954

Der moderne Bildwerferraum und seine Nebenräume (p. 300) *H. Rudolph*

Charakteristische Merkmale neuzeitlicher Bildwerfer (p. 302)

Die wichtigsten Hilfsgeräte in der Vorführkabine (p. 306) *K. Braune*

Zur Einrichtung der Vorführkabine im Schmalfilmtheater (p. 308) *K. Johanning*

Gleichrichter als Stromquelle für die Kinobogenlampe (p. 310)

Kino-Tonfilm-Verstärker im modernen Bildwerferraum (p. 312) *H. Drechsel*

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Schnelle Behebung von Störungen an Tonfilm-Verstärkern (p. 316) *H. Friedrich*

vol. 8, Nov. 1954

Gegenwärtiger Stand der Bild- und Tontechnik im Studio und im Filmtheater (p. 336) *Hans Friess*

Die Umstellung der Studiotechnik auf den Raumton (p. 339) *F. Winckel*

Grundsätzliches zur stereophonischen Tonaufnahme (p. 343) *R. Fehrmann*

Die Praxis der stereophonischen Tonaufnahme im Film (p. 344) *H.-Chr. Wohlrab*

Ein neues Mischpult für stereophonische Tonaufnahmen in der Filmtechnik (p. 346) *O. Buhler*

Vereinheitlichtes Aufbausystem für die Tonfilmwiedergabe (p. 349) *Werner Jahn*

Raumtoneffekt über einen einzigen Übertragungskanal (p. 352) *Werner Jahn*

Siemens-Projektor "2000": Ein 16-mm-Wiedergabesystem (p. 357)

vol. 8, Dec. 1954

Der Tonfilm—ein historischer Wendepunkt in Aufnahme- und Vorführtechnik (p. 372) *E. Kammerer*

Die erreichbare Tonqualität beim Lichttonverfahren (p. 378) *E. Kammerer*

Magnetton bringt Fortschritte in der Tonaufzeichnung (p. 379) *E. Kammerer*

Der Donner-Effekt, ein Problem des Lichttonfilms (p. 382) *M. Dietrich*

Der Gleichlauf im Tonfilm stellt hohe Anforderungen (p. 387) *K. Braune*

Die praktischen Grenzen der magnetischen Aufzeichnung (p. 392) *W. Guckenburg*

Siemens-Klangfilm-Geräte für die Herstellung stereophonischer Aufnahmen (p. 402) *W. Jahn*

Aufnahme- und Wiedergabe-Apparaturen für Tonfilme der Zeiss Ikon A. G. (p. 404)

Der Gleichlauf im Tonfilm stellt hohe Anforderungen (p. 383) *K. Braune*

vol. 9, Jan. 1955

Die Voraussetzungen für einwandfreie Tonwiedergabe (p. 4) *O. Diciol*

Wege zur Erzielung guter Tiefenwiedergabe bei der Konstruktion von Lautsprechern (p. 8) *E. Kammerer*

Der Einfluss der Raumakustik auf den Klangcharakter (p. 8) *H. Petzoldt*

Tagung der Deutschen Gesellschaft für Filmwissenschaft (p. 14)

Aus der Geschichte der Kinematographie *H. Tümmel*

Machine Design vol. 26, Dec. 1954

Analysis of Mechanisms with High-speed Photography (p. 206) *E. A. Edwards*

Philips Technical Review vol. 16, July 1954

Electronic Flash-Tubes (p. 13) *N. W. Robinson*

Philosophical Magazine

Series 7, Vol. 45, Oct. 1954

An Experimental Investigation of the Interaction of a Shock Wave with a Subsonic Stream Bounded by a Wall (p. 997) *D. W. Holder, A. Chinneck and G. E. Gadd*

Radio & Television News vol. 52, Aug. 1954

A Sound-Controlled Thyratron for High-Speed Photography (p. 36) *P. J. Vogelgesand and J. Hilmanowski*

Receiving Tubes for Color TV (p. 38) *W. H. Buchsbaum*

Fundamentals of Color TV; The Color Signal (p. 42) *M. S. Kiver*

vol. 53, Feb. 1955

TV Signal Tracer (p. 58) *H. E. Newton*

Oscilloscope Photography (p. 71) *E. G. Louis*

The Motorola 19" Color TV Receiver (p. 72) *M. S. Kay*

Tele-Tech vol. 14, Jan. 1955

New Color TV Projection System (p. 71)

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How to Plan for Color Television Broadcasting (p. 60) *L. E. Anderson and W. O. Hadlock*

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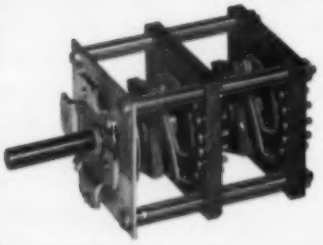

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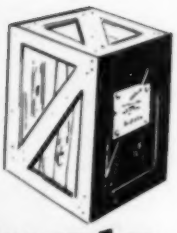

new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

The Inter Society Color Council News Letter No. 115 is a jubilee issue consisting of brief reviews of the progress made in color in the many fields covered by the Inter-Society Color Council during the editorship of the late Dr. H. I. Godlove. This, the 100th issue he had edited, was planned by Dr. Godlove just before his death as an issue of "rejoicing and accomplishment." Copies, priced at $1, may be obtained from the Secretary, Ralph M. Evans, Color Control Div., Bldg. 65, Eastman Kodak Co., Rochester 4, N.Y.

Ten Years of Semi-Conducting Materials and Transistors is a 38-page bibliography produced by the Research Dept. of Pye Limited and available from Industrial Electronics Ltd, Exning Rd., Newmarket, England. The 31 pp. of subject index is well grouped under six headings and the complete author index is keyed to these groups.

Monroe H. Sweet, former Ansco physicist, has announced the formation of the M. H. Sweet Engineering Co., with headquarters at Binghamton, N.Y. The new company consists of a Navigation Division and a Photometric Division and also serves as a consultant in the optical, photographic and aviation fields. The firm's present concentration is on the design and manufacture of air navigation devices, including autopilots, and on the development of photoelectric measuring devices such as densitometers. Associated with Mr. Sweet as chief engineer is James Casterlin, formerly of Ansco and Link Aviation, Inc.

The Swedish "Strong" projector is a complete equipment including amplifier and loud speaker (Fig. 1). The lower magazine is built into stand A itself. Tilting is effectuated by means of regulator B.

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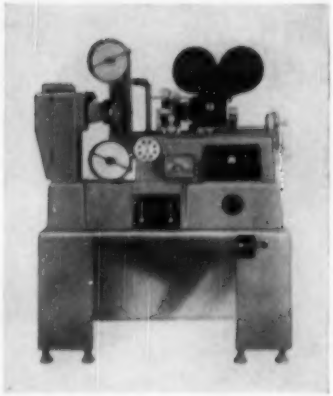

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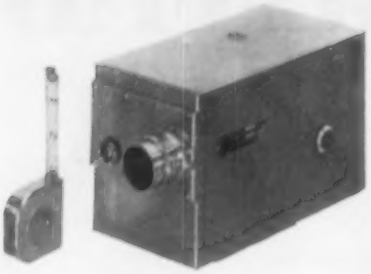

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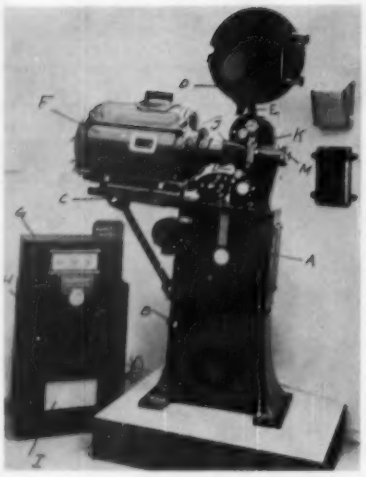

Figure 1

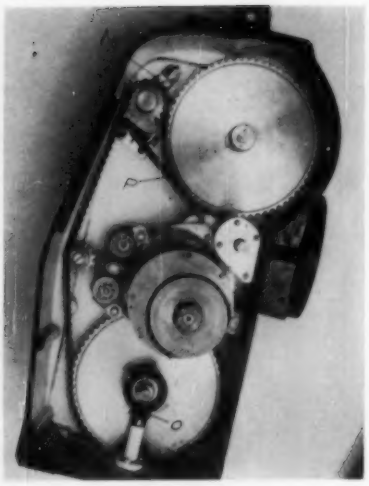

Figure 2

means of a single wheel. There are two picture operations, one for threading the film and one for projection. Handle L is used for framing the picture and is easily accessible. By means of a convenient pushbutton system the film gate is opened after the lens stand has been pushed aside. Pushing aside the lens stand provides ample space for inserting the film. Precision adjustment of the lens is solved in an ingenious way. A system of screws has been placed in a grooved cylinder M. By allowing a finger

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Figure 3

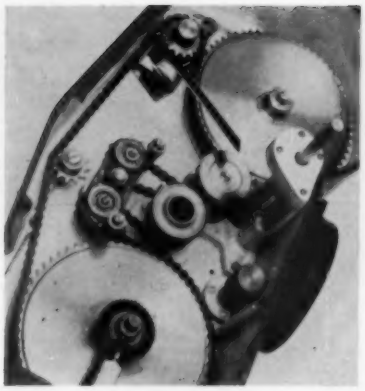

Figure 4

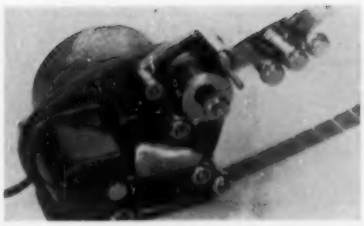

Figure 5

to glide over the cylinder the lens stand is moved into the position desired. Such precision adjustment is absolutely free of every vibration or jerk. The projector is belt-driven in order to facilitate its use with older equipment.

Figure 2 shows the interior structure of the projector. Simple and reliable transmission is achieved by means of a single chain which at the same time serves oil transportation. Thus no special pump is needed; the silent chains provide efficient oil lubrication for all parts of the projector. The silent chains provide not only safe, but also very easy, running and entirely eliminate the drawbacks of constructions with vertical axes. The chain transmission influences every machine element in projector mechanism. Spring system N acts upon a pressure cylinder which makes the chains stretch and spring. Cog-gear system O has been installed for the take-up axis built into the stand. The oil that has been brought up is lead to the intermittent movement by means of channel P. The greatest wear of a projector is in the intermittent movement. By means of a few simple movements according to Fig. 3 this entire mechanism can be exchanged without difficulty. This illustration also clearly shows axis Q with its slanting cogwheel which through the intermittent movement acts upon a mechanism for the central adjustment of the picture. Figure 4 shows the inside after dismounting the intermittent movement.

All the machine elements included are of greatest precision. Utmost care given to every detail guarantees the high quality of the projector. As demands today are very great concerning steadiness of the picture, special attention has been given to the intermittent movement. With special consideration of the deformations which so easily arise due to dirt and wear upon the velvet bands, the film trap groove insert is constructed so that it can be exchanged without difficulty.

Figure 5 shows the Strong projection soundhead. It is provided with a sound optic with antireflex treatment, which guarantees highest light gain; therefore the sound lamp used is 6 watts, 6 volts at a current power of 1 ampere. Oscillations and speed variations are balanced in the usual way by means of a softening mechanism (vacuum damping). Every guide roller is provided with self lubricating bearings.

Every care has been taken to make the construction of this projector as modern and practical as possible, including a magnetic oil filter. Every detail is as simple as possible.—Karl E. Berggren, Engineer, Amerikanak Ljudteknik AB, St. Eriksza-tan 54, Stockholm.

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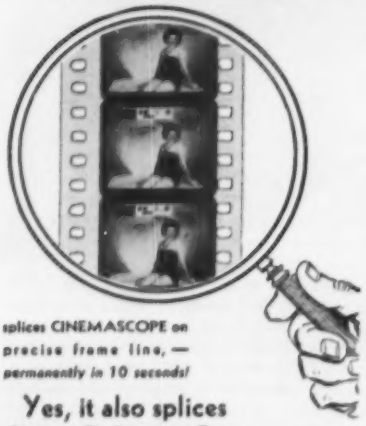

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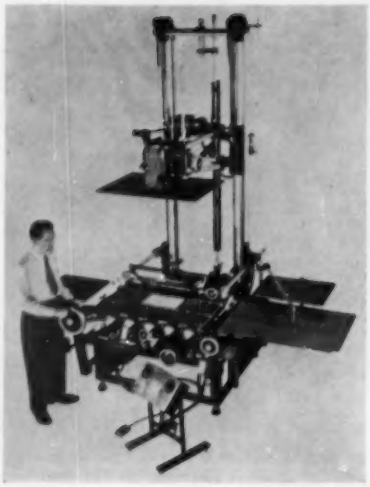

The Oxberry Animation Stand and Compound have been announced by the Animation Equipment Co., 38 Hudson St., New Rochelle, N.Y. There are available detailed descriptions, full price lists and a booklet of description covering: the stand which allows the passage of artwork 24 in. wide, the ball-bearing, counter-balanced carriage controlled either electrically or by hand, the stop-motion motor which may be switched to any of five speeds and instantly reversed without stopping, the compound which permits wide latitudes of table movement, and other standard equipment.

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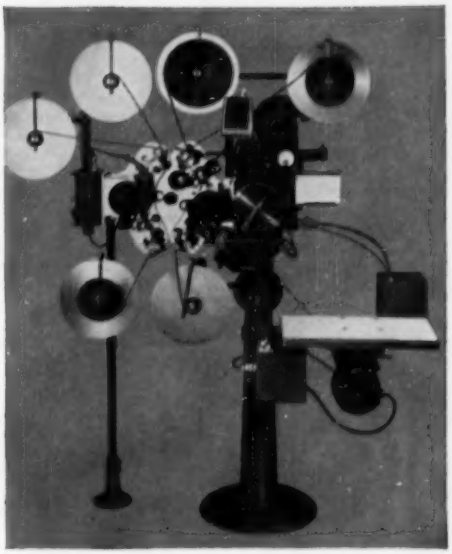

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Contents — pages 141-168

News Columns

77th Convention, Local Arrangements at Chicago, April 18–22 142
Tentative Schedule of Committee Meetings During Convention 142
Advance Program, 77th Convention 142
Section Reports 156
BOOK REVIEW 158
Theatre Catalog, 12th Annual Edition, 1954–1955, reviewed by Rowland H. Müller.
Current Literature 158
New Products 162
Employment Service 166

Advertisers

Animation Equipment Corp. 163
Bell & Howell Co. 167
Berndt-Bach, Inc. 155
Byron, Inc. 168
Camera Equipment Co. 154
Camera Mart, Inc. 152
Cinema Engineering Co. 162
Oscar Fisher Co. 150
Florman & Babb 158
General Film Laboratories, Inc. 153
Gordon Enterprises 157
Hollywood Film Co. 151
Philip A. Hunt Co. 146
Kling Photo Corp. 147
LaVezzi Machine Works 148
Motion Picture Printing Equipment Co. 145
Peerless Film Processing Corp. 156
Photo Research Corp. 159
Photo-Sonics, Inc. 143
Photovolt Corp. 160
Precision Film Laboratories, Inc. 149
Prestoseal Manufacturing Corp. 166
Professional Services 164
Reeves Soundcraft Corp. 161
SMPTE 165
TV Digest 144
Vought Co. 164
Westrex Corp. 141

Meeting Calendar

Institute of Radio Engineers, National Convention, Mar. 21–24, Kingsbridge Armory, Bronx, N.Y.

American Chemical Society, Mar. 29–Apr. 7, Cincinnati, Ohio.

American Film Assembly and Golden Reel Film Festival, Apr. 4–8, Waldorf-Astoria, New York.

Optical Society of America, Apr. 7–9, Hotel Statler, New York.

Institute of Radio Engineers, Symposium on Modern Network Synthesis, Apr. 12–15, Engineering Societies Bldg., New York.

International Symposium on Modern Network Synthesis, II, Apr. 13–15, Polytechnic Institute of Brooklyn, N. Y.

77th Semiannual Convention of the SMPTE, Apr. 18–22, Drake Hotel, Chicago.

American Society of Mechanical Engineers, Spring Meeting, Apr. 18–21, Lord Baltimore Hotel, Baltimore, Md.

American Rocket Society, Spring Meeting, Apr. 20–22, Hotels Emerson and Lord Baltimore, Baltimore, Md.

National Academy of Sciences, Apr. 25–27, Washington, D.C.

American Physical Society, Apr. 28–30, Washington, D.C.

SMPTE Central Section, May 16, June 13.

Society of Photographic Engineers, May 18–21, U.S. Thayer Hotel, West Point, N.Y.

National Society of Professional Engineers, June 2–4, Hotel Bellevue-Stratford, Philadelphia, Pa.

International Commission on Illumination, June 13–22, Zürich, Switzerland.

American Society of Mechanical Engineers, Semiannual Meeting, June 19–23, Hotel Statler, Boston, Mass.

American Rocket Society, Semiannual Meeting, June 19–23, Boston, Mass.

International Aeronautical Conference, joint mtg. of the British Aeronautical Society and the Institute of the Aeronautical Sciences, June 21–24, Los Angeles.

American Institute of Electrical Engineers, Summer General Meeting, June 27–July 1, New Ocean House, Swampscott, Mass.

Acoustical Society of America, June 30–July 2, Pennsylvania State College, State College, Pa.

Biological Photographic Association, Annual Meeting, Aug. 30–Sept. 2, Wisconsin Hotel, Milwaukee.

American Chemical Society, National Meeting, Sept. 11–16, Minneapolis, Minn.

Instrument Society of America, Sept. 12–16, Shrine Exposition Hall and Auditorium, Los Angeles.

National Electronics Conference, Oct. 3–5, Hotel Sherman, Chicago.

78th Semiannual Convention of the SMPTE, Oct. 3–7, Lake Placid Club, Essex County, N.Y.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 3–7, Morrison Hotel, Chicago.

Photographic Society of America, Oct. 5–8, Sheraton-Plaza Hotel, Boston, Mass.

Audio Engineering Society, Oct. 12–16, Hotel New Yorker, New York.

American Standards Association, 37th Annual Meeting and Sixth Annual Conference on Standards, Oct. 24–26, Washington, D.C.

American Rocket Society, Nov. 13–18, Chicago.

American Society of Mechanical Engineers, National Meeting, Nov. 13–18, Hotels Congress, Hilton and Blackstone, Chicago.

American Institute of Chemical Engineers, Nov. 27–30, Hotel Statler, Detroit.

79th Semiannual Convention of the SMPTE, Apr. 29–May 4, 1956, Hotel Statler, New York.

80th Semiannual Convention of the SMPTE, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles.

81st Semiannual Convention of the SMPTE, Apr. 28–May 3, 1957, Shoreham Hotel, Washington, D.C.

82d Semiannual Convention of the SMPTE, Oct. 6–11, 1957, Hotel Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members will be published in the April Journal.

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Producers Service Co.
Projection Optics Co., Inc.
Radiant Manufacturing Corporation
Radio Corporation of America, Engineering Products Division
Reid H. Ray Film Industries, Inc.
Raytone Screen Corp.
Reeves Sound Studios, Inc.
S.O.S. Cinema Supply Corp.
SRT Television Studios
Shelly Films Limited (Canada)
The Stancil-Hoffman Corporation
Technicolor Motion Picture Corporation
Terrytoons, Inc.
Titra Film Laboratories, Inc.
United Amusement Corporation, Limited
Wenzel Projector Company
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company